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Volume 22 JANUARY, 1948 Number 1

JOURNAL OF PALEONTOLOGY

A publication of The Society of Economic Paleontologists and Mineralogists *and* The Paleontological Society *with the generous support and cooperation of* The American Association of Petroleum Geologists *and* The Geological Society of America

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The Journal of Paleontology is published bi-monthly. The numbers issued in January, May, and September are sponsored by The Paleontological Society in cooperation with The Geological Society of America; those issued in March, July, and November are sponsored by The Society of Economic Paleontologists and Mineralogists in cooperation with The American Association of Petroleum Geologists.

The subscription price of the Journal of Paleontology is $6.00 per year prepaid to addresses in the United States.

Single numbers, $2.00 each.

Postage is charged extra for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

The Journal will furnish reprints at cost. Orders should accompany manuscript.

Communications about the Journal, subscriptions, rates, memberships, change of address, and nonreceipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 979, Tulsa 1, Oklahoma. Claims for nonreceipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to J. Marvin Weller, Walker Museum, University of Chicago, Chicago 37, Ill.

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Entered as second-class matter at the Post Office at Tulsa 1, Oklahoma, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

A publication of THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS *and* THE PALEONTOLOGICAL SOCIETY *with the generous support and cooperation of* THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS *and* THE GEOLOGICAL SOCIETY OF AMERICA

VOLUME 22 JANUARY, 1948 NUMBER 1

LOWER CAMBRIAN TRILOBITES FROM THE CONGLOMERATES OF QUEBEC (EXCLUSIVE OF THE PTYCHOPARIIDEA)

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ABSTRACT—The early Ordovician conglomerates of the lower St. Lawrence valley yield numerous fossiliferous boulders carrying Lower, Middle and Upper Cambrian faunas. In this paper the Lower Cambrian trilobites, exclusive of the ptychoparids, are described. Twenty-nine species are dealt with, 11 of which are new. The classification of Cambrian trilobites is briefly discussed.

INTRODUCTION

THE limestone conglomerates exposed at several localities in the lower St. Lawrence valley have yielded large collections, in which Lower, Middle and Upper Cambrian fossils are represented. Late Upper Cambrian trilobites occur chiefly in the conglomerates of the Lévis formation at Lévis and have been described by the writer in several papers (Rasetti, 1944, 1945a, 1945b, 1945c). An early Upper Cambrian fauna from the conglomerates of western Gaspé was described in another paper (Rasetti, 1946b). There now remain to be described the large faunas of Lower and Middle Cambrian age occurring at several localities (Rasetti, 1945d). Owing to the large number of genera and species, many of which are new, the writer plans to publish these descriptions in several papers. The present one, the first of the series, includes a portion of the Lower Cambrian trilobites.

The material on which this study is based was chiefly collected by the writer during the years 1942–45. However, several species from the area in question had been collected by Weston for the Geological Survey of Canada, and a larger amount of material was collected and described by Walcott. Resser (1938) described a few species from the conglomerates of Quebec in his monograph of the Cambrian of the southern Appalachians. All the types of the described species, mostly preserved in the U. S. National Museum, were restudied and compared with the material resulting from the writer's own collections.

The writer is greatly indebted to Dr. G. Arthur Cooper for photographing the type specimens preserved in the United States National Museum. The field expenses in 1945 were defrayed by a grant from the Penrose Bequest of The Geological Society of America.

OCCURRENCE OF THE FOSSILS

The fossils here described were collected from limestone boulders in conglomerate outcrops at several localities on the south shore of the St. Lawrence, from Lévis to Grosses Roches—a distance of about 270 miles. The writer (Rasetti, 1945d) has given

a brief report on these conglomerate outcrops and on the age of the boulders present at each locality. All these conglomerates are believed to be Lower Ordovician (Rasetti, 1946a). The boulders of various ages have in common the fact that the beds from which they came are unknown. All the boulders are of subcrystalline or fine-grained, gray, sometimes sandy limestone. Boulders of different ages (sometimes Lower, Middle and Upper Cambrian) often lie close together in the same bed and being similar or identical lithologically can be separated only on the basis of the enclosed fossils.

The trilobites are fragmentary, usually all the pieces of the shield occurring separately, but otherwise exceptionally well preserved. Most specimens preserve the test and the finest details of the surface ornamentation can be observed. Only in exceptional cases do the specimens show any trace of distortion.

Some of the boulders yield a large faunal assemblage, whereas others, although extremely fossiliferous, contain a single or very few species. The former are useful for establishing the age of new forms; the latter serve particularly well the purpose of assigning the various parts of the shield to one species. Sometimes a boulder a few pounds in weight contained thousands of well-preserved fragments of one species.

A brief account of the principal localities follows.

Lévis.—The Lévis shale at the typical locality holds the celebrated limestone conglomerates whose faunas were first described by Billings (1865) and later by Clark (1924) and the writer. Most of the boulders are either Upper Cambrian or Lower Ordovician and their faunas were described elsewhere. However, Ells (1889), Walcott (1890a) and Clark (1924) mentioned the rare occurrence of boulders with Lower Cambrian fossils. The writer now records for the first time the presence of boulders carrying a Middle Cambrian fauna. These boulders seem to be relatively abundant in a conglomerate bed outcropping just north and east of the Fort no. 1. However, only a few fossils were recovered from these boulders (mainly species of *Kootenia*) and since all these species occur in greater abundance elsewhere, the Middle and Lower Cambrian fossils from Lévis will not be mentioned further.

Ville Guay and Island of Orléans.—A bed recently designated by the writer (Rasetti, 1946a) as the Ville Guay conglomerate outcrops at Ville Guay, 4½ miles east of Lévis, and on the opposite shore of the Island of Orléans. This conglomerate was first mentioned by Ells (1889) and a few fossils from its boulders were described by Walcott (1890b), Clark (1924), Resser (1938) and the writer (Rasetti, 1945e). It was first believed that all the fossils from the Ville Guay conglomerate were Lower Cambrian, but the writer is now convinced that an early Middle Cambrian fauna is also represented.

Boulders from Ville Guay are designated by the letter L, boulders from the Island of Orléans by the letter O.

Trois Pistoles.—This locality lies about 150 miles northeast of the preceding ones. The conglomerate is exposed on the shore 1 mile west of the wharf of Trois Pistoles. So far the boulders have yielded only Lower Cambrian fossils.

Boulders from Trois Pistoles are designated by the letters TP.

St. Simon.—The conglomerate outcrops on the shore about 1 mile east of the wharf of St. Simon. Most of the boulders yield Lower Cambrian fossils but a species, *Agraulos redpathi*, described by Walcott (1890b) from this locality and so far considered Lower Cambrian is now believed by the writer to be Middle Cambrian.

Boulders from St. Simon are designated by the letters SS.

Bic.—The conglomerates are exposed for several miles east and west of Bic, associated with great thicknesses of quartzite. Conglomerate and quartzite form the abrupt hills, sculptured by Pleistocene glaciers, to which the area owes its rugged topography.

The early collectors of the Geological Survey of Canada secured Cambrian fossils from Bic. Some of the species were described by Billings (1872), Walcott (1912, 1916) and Resser (1938). Most of the fossils are Lower Cambrian, but the writer recently collected a boulder yielding Middle Cambrian species.

Boulders from Bic are designated by the letter B.

Métis.—Conglomerate outcrops occur at

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several places in the Métis area, but the best collecting is from the erratic masses of conglomerate strewn along the shore and the fields between Little Métis and Baie des Sables.

Walcott (1890b) described a trilobite from this locality; the species, *Ptychoparia metisensis*, was then believed to be Lower Cambrian, but its associations prove that it is of late Middle Cambrian age.

The conglomerates of the Métis area supply vast numbers of fossiliferous Lower, Middle and early Upper Cambrian boulders.

Boulders from Métis are designated by the letter M.

Grosses Roches.—The locality lies in Matane County, about 55 miles east of Métis. Richardson (1859) first reported the existence of conglomerates in this area, and Ells (1883) briefly mentions collecting Cambrian fossils from the boulders. The writer recently described the Upper Cambrian trilobites from Grosses Roches and Métis.

The most extensive and accessible outcrops of conglomerate in place are on the shore, two to three miles east of the outlet of the Ruisseau à la Loutre. Erratic masses of conglomerate are widely scattered in the area. Grosses Roches is the most fossiliferous of all the localities discussed, especially for Middle Cambrian fossils.

Boulders from Grosses Roches are designated by the letter G.

AGE OF THE FAUNAS

Since all the fossils here described were recovered from conglomerate boulders, considerable care is required in order to establish the various faunal assemblages present in the strata from which the boulders were derived. Each specimen was labeled according to the boulder from which it was collected and after all the forms had been studied and the species occurring in each boulder had been tabulated several clear-cut assemblages emerged.

The first problem that presents itself is which of the faunal assemblages should be considered Lower Cambrian and which Middle Cambrian. Faunas containing olenellids can be definitely considered Lower Cambrian, but some uncertainty may exist for assemblages from which olenellids are absent.

Resser (1933; 1938) and Howell (1944) have admitted a post-olenellian Lower Cambrian zone in the Appalachian and Cordilleran provinces, but the evidence so far published in favor of this decision appears to the writer rather scanty and unconvincing. Until the late Lower Cambrian and early Middle Cambrian faunas of the Cordilleran sections are better studied the problem cannot be solved. Here the assemblages from which olenellids are absent are classified as Middle Cambrian. This conclusion is supported by the fact that most of their genera are typically Middle Cambrian.

The undoubted Lower Cambrian boulders whose faunas are discussed in this paper probably come from several slightly different horizons. In general, the writer's impression is that the assemblage found in the boulders of the Ville Guay conglomerate (and in some of the boulders at Grosses Roches) is somewhat younger than most of the fossils collected at Bic, St. Simon and Trois Pistoles. Even lithologically there is some difference in the boulders of the two types; the former are usually dark-gray; the latter consist of a light-gray, hard, sometimes sandy limestone. Olenellids and species of *Bonnia* (usually different, but one species, *B. laevigata*, seems common to all types of limestone and all localities) occur in both limestones. The Ville Guay assemblage contains in addition several genera, particularly *Pagetides*, *Periommella*, *Austinvillia* and *Kootenia*, that have not been found in the light-gray limestone, and especially on the evidence of the last of these genera is considered younger than the other.

The fauna from the light-gray limestone at Bic and other localities is undoubtedly very similar to that occurring in the reefs of the Shady formation at Austinville, Virginia and in the Forteau formation of Labrador and western Newfoundland. The other assemblage is close to the fauna of the Parker shale of Vermont and the Kinzers formation of Pennsylvania.

Table 1 gives a list of the species collected from each boulder. The last three species of the list are ptychoparids, not discussed in this paper.

TABLE 1. FAUNAS OF THE LOWER CAMBRIAN BOULDERS

Boulder	L2	L11	O1	O20	O25	TP1	SS1	B1	B2	B4	B5	B6	B9	B10	B11	B14	M10	G9	G15	G17	G21	G24	G25	G27	G41
Bonnia bicensis Resser													x												
Bonnia brennoides Rasetti, n. sp.																		x							
Bonnia brennus (Walcott)											x				x				x						
Bonnia bubaris (Walcott)														x											
Bonnia crassa Resser									x			x									x				
Bonnia laevigata Rasetti, n. sp.	x					x		x									x			x		x			x
Bonnia occipitalis Rasetti, n. sp.																x									
Bonnia sculpta Rasetti, n. sp.																				x					x
Bonnia senecta (Billings)																								x	
Bonnia similis Rasetti, n. sp.					x																				
Bonnia tensa Resser																							x		
Bonnia sp. undet.			x																						
Dolichometopsis? bicensis Rasetti, n. sp.										x		x													
Dolichometopsis? minor Rasetti, n. sp.																x									
Kootenia cf. *marcoui* (Whitfield)																						x			
Pagetides amplifrons Rasetti	x			x																					
Pagetides elegans Rasetti		x																				x			
Pagetides leiopygus Rasetti	x			x																					
Pagetides minutus Rasetti			x																						
Pagetides rupestris Rasetti, n. sp.																						x			
Protypus marginatus Rasetti, n. sp.								x		x					x	x									x
Protypus reticulatus Rasetti, n. sp.						x	x																		
Protypus typicus (Resser)																	x					x			
Prosacanthoides sp. undet.		x					x			x												x			
Zacanthopsis virginica Resser							x										x		x					x	
Undetermined Olenellidae		x			x							x	x									x			
Austinvillia bicensis Resser			x																						
Periomma walcotti Resser	x																								
Periommella yorkensis Resser	x	x		x																		x			

CLASSIFICATION OF CAMBRIAN TRILOBITES

A general discussion of the classification of the trilobites as a whole, or even of the Cambrian forms, is not within the scope of this paper. However, a few remarks are required in order to explain the classification adopted.

The classification of Cambrian trilobites has been discussed by many authors, especially Beecher (1897), Swinnerton (1915), Raymond (1917), Warburg (1925), Poulsen (1927), Richter (1932), Kobayashi (1935, 1939), Whitehouse (1936, 1939) and Størmer (1942). Combining the results of several of the latest authors, especially Warburg,

EXPLANATION OF PLATE 1

The test is preserved in all the figured specimens unless otherwise indicated.

The figured fossils are from the conglomerates of the lower St. Lawrence valley unless the locality is indicated.

FIGS. *1–2—Pagetides elegans* Rasetti, ×6. *1, 2*, Top and side views of cranidium; Laval U. 304a, holotype. *3*, Pygidium; Laval U. 304b, paratype. (p. 11)

4–6—Pagetides elegans Rasetti. *4*, Specimen lacking the test, preserving cephalon and portions of thorax and pygidium, ×4. *5, 6*, Artificial casts of cranidia, ×6. Parker shale (*Olenellus* zone); Kelly quarry, ½ mile east of Swanton Junction, Vermont. Laval U. 315a–c, plesiotypes. (p. 11)

7—Pagetides elegans Rasetti, ×6. Exfoliated cranidium. Schodack formation; west side of Route 286, 3.7 miles north of Middle Granville, Washington County, New York. Laval U. 316, plesiotype. (p. 11)

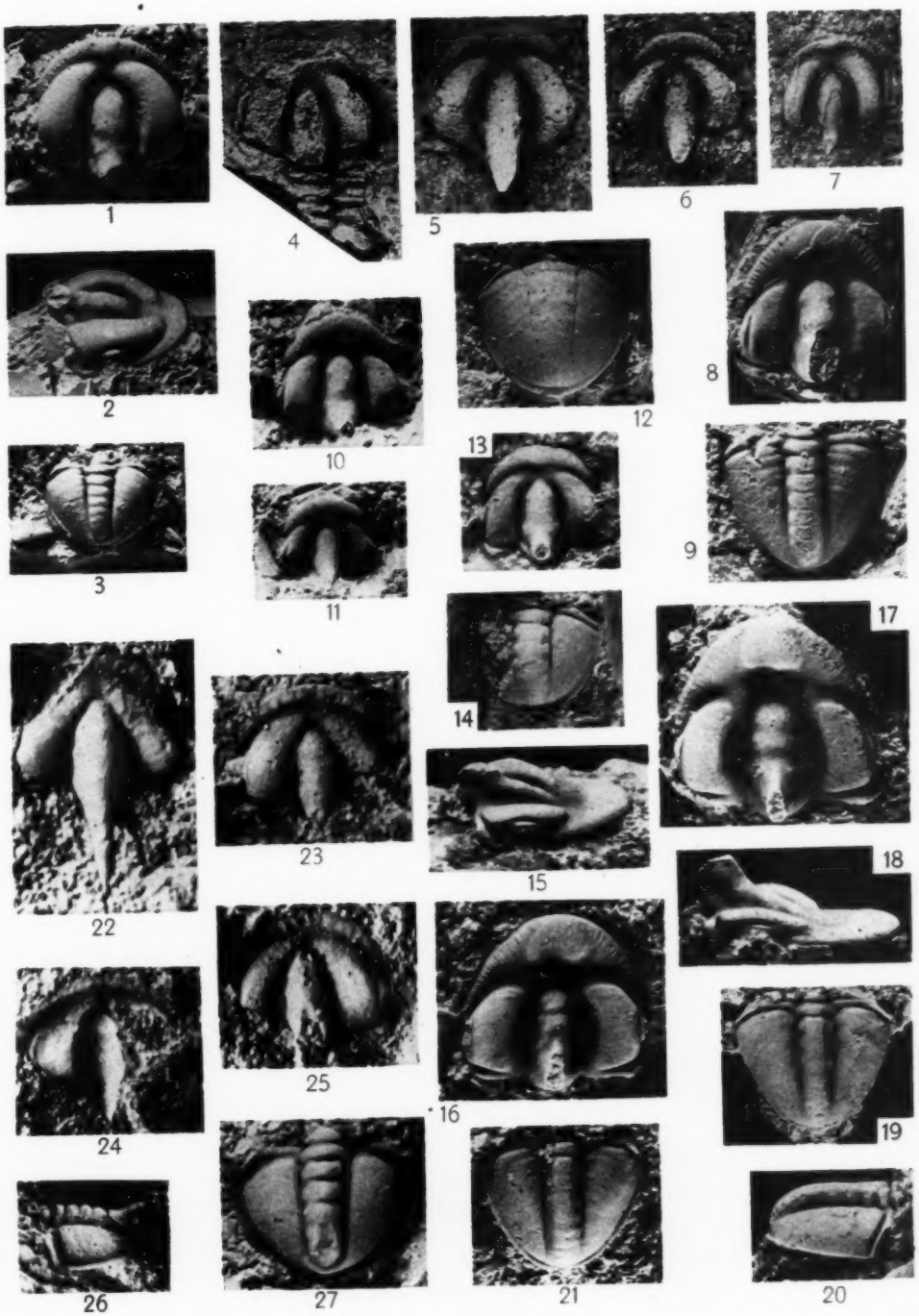
8, 9—Pagetides amplifrons Rasetti, ×8. *8*, Cranidium; Laval U. 300a, holotype. *9*, Pygidium; Laval U. 300b, paratype. (p. 12)

10–12—Pagetides leiopygus Rasetti, ×8. *11*, Cranidium; Laval U. 301a, holotype. *10*, Another cranidium; *12*, Pygidium; Laval U. 301b–c, paratypes. (p. 12)

13–14—Pagetides minutus Rasetti, ×8. *13*, Cranidium; Laval U. 302a, holotype. *14*, Pygidium; Laval U. 302b, paratype. (p. 12)

15–21—Pagetides rupestris Rasetti, n. sp. *15, 16*, Side and top views of cranidium, ×8; Laval U. 317a, holotype. *17, 18*, Top and side views of another cranidium, ×8. *19, 20*, Top and side views of pygidium, ×5. *21*, Another pygidium, ×8; Laval U. 317b–d, paratypes. (p. 12)

22–27—Pagetia connexa (Walcott), ×15, *22–25*, Cranidia. *26, 27*, Pygidia. Schodack formation; south side of U.S. 4, ¼ mile west of bridge on Poultney River, near Low Hampton, Washington County, New York. Laval U. 318a–f, plesiotypes. (p. 13)



Rasetti, Lower Cambrian Trilobites

Rasetti, Lower Cambrian Trilobites

Richter and Whitehouse, with whose ideas the writer agrees in most instances, the following relevant points may be considered as fairly well established.

(1) The ancestors of the trilobites had already become differentiated into several distinct groups in the pre-Cambrian, before acquiring a hard test and being capable of fossilization (Whitehouse, 1939). Possibly new groups continued to develop from soft forms during most of the Cambrian and through the early part of the Ordovician. Hence there is no certainty that the Lower Cambrian trilobites capable of fossilization are the ancestors of all the later forms.

(2) A phylogenetic classification of trilobites cannot be based on a single character. The major subdivisions must be based on a complex of features, each rather unimportant in itself, but acquiring significance through its association with other characters.

It is now an established fact that almost any single character of the trilobite shield suggested as the basis for the distinction of major groups is so unimportant that closely related forms can be pointed out differing precisely in that particular feature. This indicates that *the essential differential characters that may have existed in the living animal were not expressed in clear-cut single features of the dorsal shield*, the only part usually available to us.

When the important characters on which taxonomic distinctions should have been based are not accessible, the only acceptable criterion for affinity is the existence of a series of intermediate forms continuous morphologically and chronologically. Conversely, discontinuities in apparently insignificant characters of the fossil shield may indicate that these characters were expressive of important differences in the internal organization of the animal. It is almost unnecessary to point out that discontinuities may be simulated by the incompleteness of the fossil record.

(3) The usefulness of ontogeny for establishing the phylogeny was greatly overestimated by Beecher and other early authors. From the standpoint of modern embryology there is little reason to assume that larval forms represent ancestral forms (De Beer 1936, 1939).

(4) Beecher's order Hypoparia is an incongruous assemblage of widely separated forms and has no phylogenetic significance (Swinnerton, 1915; Ulrich, 1922; Warburg, 1925; Richter, 1932; Stubblefield, 1936; Rasetti, 1945a). Hence this order must be suppressed and its members distributed among other groups. The same objections hold against Poulsen's order Integricephalida. Størmer (1942) is the only recent author who has given the order Hypoparia at least the benefit of the doubt.

In the writer's opinion the post-Cambrian "Hypoparia" such as *Trinucleus*, *Harpes* and *Loganopeltis* are Opisthoparia in which the facial sutures have become fused, with simultaneous development of a marginal suture; these forms should be placed in the Opisthoparia. The Cambrian "Hypoparia,"

EXPLANATION OF PLATE 2

The test is preserved in all the figured specimens unless otherwise indicated.
All the figured fossils are from the conglomerates of the lower St. Lawrence valley.

FIGS. *1–3—Callavia bicensis* Walcott, ×2. *3*, Cephalon lacking the test. *1*, *2*, Artificial cast of counterpart of same specimen in top and side views; USNM 56794, holotype. (p. 10)
4—Wanneria? sp. undet., ×1. Cephalon lacking the test. Laval U. 313. (p. 10)
5, *6—Paedeumias* sp. undet. *5*, Young well-preserved cephalon, ×6. *6*, Cephalon lacking the glabella, ×2.5; Laval U. 312a–b. See also Fig. *20*. (p. 10)
7—Kootenia cf. *K. marcoui* (Whitfield), ×2.5. Pygidium; Laval U. 319. (p. 14)
8–11—Dolichometopsis? bicensis Rasetti, n. sp. *8*, *9*, Top and side views of cranidium, ×4; Laval U. 332b, paratype. *10*, *11*, Top and side views of a smaller cranidium, ×5; Laval U. 332a, holotype. (p. 21)
12–16—Dolichometopsis? minor Rasetti, n. sp. *13*, Cranidium, ×5; Laval U. 331a, holotype. *12*, Small, almost complete shield, ×8. *14–16*, Three cranidia, ×5; Laval U. 331b–e, paratypes. (p. 20)
17–19—Zacanthopsis virginica Resser, ×3. Three cranidia; Laval U. 333a–c, plesiotypes. (p. 21)
20–24—Prozacanthoides sp. undet. *20*, Cranidium, associated with cephalon of *Paedeumias*, ×2. *21*, *22*, Cranidia, possibly representing different species, ×3. *23*, *24*, Pygidia, ×3; Laval U. 334a–e. (p. 22)

the Agnostida and the blind Eodiscida, almost certainly do not possess any cephalic sutures (apart from a hypothetical hypostomal suture) since the doublure forms a single piece with the dorsal shield. This fact, which for obscure reasons seems to have been usually disregarded in discussing these trilobites, eliminates the last possible reason for uniting the Agnostida and Eodiscida with the post-Cambrian "Hypoparia."

(5) Beecher's order Proparia probably represents a natural unit and may be retained, provided spurious forms that have been assigned to it be eliminated. Among these are the Calymenidae, which have doubtfully proparian sutures and in all other characters show close relationship with the opisthoparian Ptychopariidae. The few Cambrian families of trilobites with proparian sutures (Pagetiidae, Norwoodiidae, Burlingiidae and, doubtfully, Menomoniidae) have little in common with the true post-Cambrian Proparia, and also with each other. There is no indication whatsoever that any of these families represent the ancestors of the post-Cambrian Proparia; it is rather likely that the proparian condition of the facial sutures arose independently in widely separated groups.

(6) Once the order Hypoparia is suppressed and the order Proparia limited to post-Cambrian forms, Beecher's classification becomes useless when applied to Cambrian trilobites.

(7) The Olenellida have been considered as a separate order by recent authors (Poulsen, 1927; Resser, 1938). However, some writers (Swinnerton, 1916; Kobayashi, 1935; Whitehouse, 1939) included in the Olenellida forms with perfectly well-developed facial sutures (e.g. *Zacanthoides*) which, in the writer's opinion must be eliminated. Recent studies show that *Zacanthoides* is related to a number of Cambrian Opisthoparia through an almost continuous series of forms (e.g. *Prozacanthoides*, *Dolichometopsis*, *Ptarmigania*, *Clavaspidella*, *Bathyuriscus*, etc.), whereas there is a deep gap between the Olenellidae lacking facial sutures and all these other trilobites.

(8) The agnostids have been considered a sharply separated group by many authors, beginning with Barrande, and recently by Howell (1935), Whitehouse (1936, 1939), Kobayashi (1935, 1939) and Resser (1938). The last author went so far as to consider the agnostids as a separate subclass equal in rank to the trilobites, without stating the reasons for this procedure. Although this may be an overstatement of the importance of the group, the writer inclines to believe that the gap between the agnostids and all the other trilobites is wider than any other existing within the subclass. Jaekel (1909) and Whitehouse (1939) expressed this belief by dividing the trilobites into two orders, Miomera and Polymera, the first including the agnostids and eodiscids and the second all the multisegmented trilobites. Resser and the writer disagree with Kobayashi and Whitehouse, in that, in their opinion, the eodiscids should not be united with the agnostids but are rather more closely related to the multisegmented trilobites. The reasons for this belief will be briefly stated.

The chief distinctive characters of the agnostids are: (1) the specialization of the pygidial segments; (2) the probably constant number of segments represented in the pygidium; (3) the constant number of thoracic segments; (4) the complete lack of cephalic sutures in all forms.

It cannot be denied that the agnostid pygidium is a very different structure from the usual pygidium of the other trilobites, including the eodiscids. In most of these trilobites, and in particular in all the less specialized Cambrian forms, the pygidial segments differ very little from thoracic segments, except in being fused. The number of fused segments varies even among closely related species, and so does the number of free thoracic segments. In the agnostids, on the contrary, the pygidium is a most peculiar structure, in which the fused segments have been greatly differentiated and bear little resemblance to the thoracic segments. In fact, their specialization seems to have advanced as far as the specialization of the fused cephalic segments. A well known consequence expressive of this fact is that there has been a great deal of discussion about which of the shields represents the cephalon and which the pygidium; a doubt that cannot arise for any other group of arthropods.

Moreover, the writer cannot escape the impression that there is a *constant* number of segments represented in the agnostid

pygidium. All agnostid pygidia are built exactly on the same plan, differing only in the course and degree of development of the furrows; they can all be easily reduced to the same model without assuming that there are different numbers of segments in the different genera and species. Every student of trilobites has assumed that the trilobite cephalon (and, in particular, the agnostid cephalon) represents a constant number of fused segments; there is then every reason to assume the same for the agnostid pygidium which is an entirely analogous structure. This great specialization of the pygidial segments must have corresponded to the development of particular anatomic features of the portion of the animal covered by the pygidial shield.

If this interpretation is correct, then the total number of body segments of the agnostids was constant, since the thorax has invariably two segments, and nobody has ever claimed a variable number of segments in the cephalon. This is in striking contrast with the situation obtaining in all the other trilobites, inclusive of the eodiscids, where a variable number of body segments, even among the most closely related species, is the rule.

Moreover, the distinction between the agnostids and all the other trilobites is absolutely sharp: there is no known form which bridges the gap. The agnostids, an excessively conservative group, appear with all their characteristic features in the late Lower Cambrian and show practically no evolution during their life span that extends to the end of the Ordovician. It is clear that the ancestors of the agnostids and of the other trilobites had already become well differentiated in the late pre-Cambrian, before these arthropods acquired a hard carapace and became capable of fossilization in ordinary sediments.

The Agnostida will be here considered as an order, that is given equal standing with the Olenellida, the Opisthoparia, the Proparia and the Eodiscida, although in the writer's opinion they should deserve a taxonomic group of higher rank.

(9) Whitehouse (1936; 1939) and the writer (Rasetti, 1945b) have stated the reasons for considering the eodiscids a separate group. They are set off from the agnostids by the characters discussed in the preceding section. The eodiscids differ from all the other trilobites in the small number of thoracic segments (two or three) whereas all the other trilobites, as far as known to the writer, possess at least five thoracic segments in the adult form. The number of thoracic segments in trilobites is usually of little taxonomic value, but in the present case this character is accompanied by a number of other features that make the eodiscids a highly distinctive and homogeneous group. They either entirely lack cephalic sutures, or possess small free cheeks of the proparian type. However, there seems to be no justification for uniting them with the true post-Cambrian Proparia, with which they have nothing else in common. Furthermore, the eodiscids became extinguished with the close of the Middle Cambrian without showing any significant modification in comparison with the Lower Cambrian forms, and we have every reason to assume that they left no descendants.

The Eodiscida will be here considered as an order.

(10) After setting off the Olenellida, the Agnostida and the Eodiscida as separate orders, in the writer's opinion there is no justification for separating other groups of equivalent rank among the remaining Cambrian trilobites. It is unfortunate that the remaining group is of much greater scope than the three readily recognizable orders, but its subdivision is exceedingly difficult owing to intermediate forms crossing almost any of the dividing lines that have been suggested. Hence, at least for the present, all we can do is to place all these trilobites in one order and recognize a number of families and superfamilies, although boundaries sharp enough even for family distinction are seldom encountered. The order Opisthoparia seems to be the appropriate name for this large assemblage, since the great majority of its members have opisthoparian sutures.

Attempts toward a classification of this immense array of forms have been made by Poulsen (1927), Richter (1932), Kobayashi (1935) and Whitehouse (1939). Although each of these authors has contributed valuable ideas, we are still far from a satisfactory arrangement of the Cambrian Opisthoparia. As has been emphasized by Resser (1942a,

1942b), the number of known forms is far too small in comparison with the number that lived in the Cambrian seas to attempt a definitive classification. The Lower Cambrian and most of the Middle Cambrian forms fall within relatively well-defined groups, but the large and varied assemblages of Upper Cambrian Opisthoparia that have been recently brought to light defy any attempt at classification.

(11) In this and the following papers we are concerned only with the Lower and Middle Cambrian forms from the Appalachian province. The classification of the Opisthoparia within these stratigraphic and geographic limits is particularly simple, since all the known forms readily fall within one or the other of two groups used by Richter, Kobayashi and Whitehouse.

One of these groups is the Richters' superfamily Ptychopariidea, the other corresponds to Richters' Zacanthoididea and Bathyuriscidea which the writer finds difficult to separate in view of the presence of a number of intermediate genera. Richter associated to each of these superfamilies of Cambrian trilobites a number of post-Cambrian families which he assumed to be their descendants; this point shall not be discussed here as beyond the scope of this paper. Kobayashi and Whitehouse used the suborder Corynexochida much in the same sense as Richters' Bathyuriscidea; both still separating the Zacanthoididea from this group and placing them with the Olenellidae in the suborder Mesonacida. The writer is unable to see any convincing reason for this procedure which places closely related, sometimes almost indistinguishable genera in two different suborders.

Here the superfamily Bathyuriscidea will be used to include the Cambrian families Corynexochidae, Bathyuriscidae, Dorypygidae, Zacanthoididae, Oryctocephalidae and a number of genera not yet assigned to families.

The Ptychopariidea are characterized by the following features. Glabella almost invariably tapered, generally much shorter than the whole head; frontal brim or at least the border, well developed; thorax almost always with more than 12 segments in the micropygous forms, often with as many as 16–24 segments. Pygidium simple and very small in the lower Cambrian and the early Middle Cambrian forms, attaining large dimensions in late Middle Cambrian genera. Characteristic genera in the Lower Cambrian are *Antagmus*, *Proliostracus*, *Periomma*, *Kochiella*, *Inglefieldia*, *Poulsenia*. In the Middle Cambrian, *Ptychoparia*, *Elrathia*, *Elrathina*, *Solenopleura*, *Alokistocare*, *Acrocephalops* and several scores of other genera are examples of micropygous forms. *Asaphiscus* and *Glyphaspis* are examples of the macropygous Ptychopariidea that began to appear in late Middle Cambrian time.

The Bathyuriscidea are characterized, first of all, by a glabella that occupies all or most of the length of the cephalon and expands toward the front. These characters are associated with a smaller number of thoracic segments, not exceeding 10 even in the Lower Cambrian micropygous forms and mostly comprised between seven and nine. Macropygous forms are already common in the Lower Cambrian. The pygidia are much more varied in shape than in the Ptychopariidea and often supply important generic characters.

Typical Lower Cambrian genera of the Bathyuriscidea are: *Prozacanthoides*, *Dolichometopsis*, *Bonnia*. In the Middle Cambrian there is a great development of the group, represented by *Albertella*, *Zacanthoides*, *Ptarmigania*, *Bathyuriscus*, *Athabaskia*, *Glossopleura*, *Ogygopsis*, *Kootenia*, *Olenoides*, *Corynexochus* and many other genera.

It must be emphasized that the division of the Cambrian Opisthoparia into Ptychopariidea and Bathyuriscidea is by no means exhaustive, other groups of equivalent rank having to be recognized especially outside of the Appalachian and Cordilleran provinces of North America.

It is difficult and often impossible to trace the ancestry of many Upper Cambrian trilobites, in particular to decide whether they are descendants of the Ptychopariidea, the Bathyuriscidea or other groups of Lower and Middle Cambrian age. This may be partly due to the reason explained in paragraph (1), partly to a convergence of the Ptychoparid and Bathyuriscid stocks after the end of the Middle Cambrian.

Family divisions proposed for the Bathyuriscidea by several authors seem fairly satisfactory, at least with some modifications

brought by the recent considerable increase in the number of known genera. The classification of the Ptychopariidea is in a state of great confusion and little hope of progress exists until many more forms are described, correlation on a world-wide scale becomes more accurate and many of the described forms become known from more complete individuals. For this reason the writer will arrange the ptychoparid genera in alphabetic order without attempting a division into families.

INTRASPECIFIC VARIABILITY IN CAMBRIAN TRILOBITES

Some of the highly fossiliferous boulders whose faunas will be described in this and succeeding papers afford excellent means of studying the intraspecific variability of Cambrian trilobites. Whenever we find hundreds of triolobite shields within a small piece of rock, we have a rather large sample of a practically contemporaneous population. If the individuals within this population show a certain variability, but there are no gaps between the different forms, there is no doubt that we have to do with a single species; that is, with a group of individuals which would be considered conspecific by the standards applied to living organisms by modern taxonomists.

These circumstances, coupled with the lack of distortion and excellent state of preservation, have permitted a good evaluation of the limits of variability of several of the species described in this work or to be described in successive papers. An extensive study of this question would be worth while, especially if a quantitative statistical analysis of the variation were carried out. However, this is considered beyond the scope of this paper, and here we shall limit ourselves to a brief qualitative discussion.

Intraspecific variability in the Cambrian trilobites investigated affects more or less all parts of the carapace, but some features were observed to be more variable than others. Some of the variable characters noticed are listed below.

The shape of the glabella was observed to vary in several species; undistorted specimens of approximately equal size were compared for this purpose. For example, the glabella may taper somewhat more or less rapidly; the anterior outline may be more sharply truncated or more rounded. The depth of the glabellar furrows is particularly subject to variability. In certain species, where the furrows are shallow, some individuals do not show them at all, others will show a faint trace of one pair, others of two pairs. Of course all these individuals were compared under the same conditions of preservation, usually by observing the upper surface of the test.

The shape of the brim and border and the depth of the marginal furrow that separates them are subject to considerable variation. The brim may be more or less inclined; the angle between the brim and border may vary; and the border itself may be more or less convex.

One of the most variable characters is the size of tubercles and spines on all parts of the shield. The occipital node or spine is an outstanding example. In some species one may observe a series of individuals in which the occipital node gradually changes into a short spine.

The surface ornamentation is also a variable character. In the species where it consists of small tubercles, the number of tubercles may vary quite considerably from one individual to another, sometimes by a factor of two or three.

Similar features are observed on the thorax and pygidium. Among the variable characters most often observed on pygidia are the depth of the axial furrows; the depth of the pleural furrows and interpleural grooves; and the size of axial or marginal spines when present.

An idea of the quantitative limits of variability will be given by the illustrations of some of the species.

A conclusion drawn by the writer from this preliminary study is that a great many species of Cambrian trilobites that have been described by authors upon one or two, often poorly preserved individuals, and separated from other species on the basis of small differences, have little chance of being valid species. By choosing three or four different individuals among a population from one of the highly fossiliferous boulders and ignoring the intermediate forms, one would have better evidence for making as many different species than has been deemed

sufficient by several authors. A still worse habit in which certain authors have indulged is to make separate species for specimens from distant localities in the absence of appreciable morphologic differences.

The practical consequence of these considerations is that the writer has been conservative in making new species. Whenever two species were separated upon small differences, large numbers of individuals of each were required and it was ascertained that for example, all the population from one boulder presented the characters of one type and all that from another boulder different characters. Of course, this still does not prove that if a third boulder had been collected (whose original stratigraphic position was intermediate between the two first-mentioned boulders) it might not have contained a fauna intermediate in character between the other two. This is an unavoidable difficulty in paleontology. As has been recently pointed out by several students of evolution and taxonomy (Simpson, 1943; Dobzhanski, 1944) contemporaneous species can be separated by more or less objective biological criteria but no such separation is possible in the vertical dimension.

TERMINOLOGY

A few remarks on terminology are necessary, because the writer will use for the first time in this paper the unified terminology for describing Cambrian trilobites recently proposed by Howell, Frederickson, Lochman, Raasch and Rasetti (1947). These remarks will cover only those points where the differences between the new terminology and that previously used by the writer might lead to confusion.

Whereas the writer in his earlier papers used the term "brim" to designate all the portion of the cranidium in front of the glabella, in the new terminology brim signifies the area limited by: the dorsal furrows, the ocular ridges, the anterior branch of the facial suture and the marginal (formerly "anterior") furrow. The area in front of the marginal furrow is designated as border (formerly "rim"). The lateral parts of the brim in its present meaning were formerly included in the fixed cheeks.

The fixed cheek in its present meaning is bounded by: the dorsal furrow, the ocular ridge, the facial suture along the edge of the palpebral lobe, and a straight line drawn from the posterior end of the palpebral lobe to the inner end of the posterior marginal furrow. The area outside of this line is called "posterior limb."

The width of the fixed cheeks given as a fraction of the glabellar width *includes* the palpebral lobes.

All the descriptions refer to the outer surface of the test unless otherwise indicated.

SYSTEMATIC DESCRIPTIONS

ORDER OLENELLIDA

Family OLENELLIDAE Vogdes

Olenellid tests occur in several of the Lower Cambrian boulders, but are generally too fragmentary even for generic identification. The few specimens described and illustrated add nothing to our knowledge of the group, and are chiefly recorded in order to prove the Lower Cambrian age of the fauna.

Genus PAEDEUMIAS Walcott, 1910

PAEDEUMIAS sp. undet.

Plate 2, figures 5, 6

Cephala occurring in several boulders of the Ville Guay conglomerate are assigned to *Paedeumias* because of the considerable distance between the glabella and the anterior border. One of the figured specimens is immature but very well preserved.

Boulders L-6 and L-11, Ville Guay and 0–31, Island of Orléans.

Figured specimens: Laval University nos. 312 a–b.

Genus CALLAVIA Matthew, 1897

CALLAVIA BICENSIS Walcott

Plate 2, figures 1–3

Callavia bicensis WALCOTT, 1910, Smithsonian Misc. Coll., vol, 53, no. 6, p. 277, pl. 41, figs. 9, 9a.

There is nothing to be added to Walcott's original description of the species.

Bic (boulder unknown).

Holotype and plesiotype: USNM no. 56794.

Genus WANNERIA Walcott, 1910

WANNERIA? sp. undet.

Plate 2, figure 4

Fragments of Olenellids are tentatively assigned to *Wanneria*, but they might belong to *Olenellus*.

An incomplete cephalon lacking the test is figured.

Boulder B-6, Bic.

Figured specimen: Laval University no. 313; other specimens: Laval University nos. 314 a-c.

Order Eodiscida

The writer (Rasetti, 1945d) pointed out the reason for recognizing the Eodiscida as a separate order, and further arguments have been discussed in an earlier section of the present paper.

The fact is now called to the writer's attention that Kobayashi (1943) had attempted a revision of the group. There is no doubt that a revision of the Eodiscida is highly desirable, but work of the type of that done by Kobayashi is more apt to lead to further confusion than to clear up the problem. He obviously did not have any of the types of the European and North American species available, so that the characters and affinities of the described species had to be judged by old descriptions and illustrations. The result is that Kobayashi had an entirely false conception of many forms and placed them in the wrong systematic position. There is little doubt that in several instances he made different species, or even genera, for the same form, on the strength of the different appearance suggested by old, very poor figures published by Dawson, Matthew and Walcott. It is even questionable whether some of the new species and genera can be recognized according to the Rules of Zoological Nomenclature. In fact, Kobayashi designated as types of new species (sometimes simultaneously designated as genotypes) figures published by the above-mentioned authors. There is nothing in the respective publications to designate the specimens which the illustrations are supposed to represent. It is likely, according to the habits of many paleontologists of the last century, that these figures do not represent any particular specimen, but only the author's conception of a form deduced from the observation of many specimens. It is obvious that species must be based on specimens; a figure will do as a designation of a holotype only insofar as it represents a definite, identifiable and actually existing specimen; so that the designation really refers to the specimen. A species cannot be based on a figure representing an author's generalized idea of a certain form.

This case represents one more example of the rule that no useful revision of a group can be undertaken without studying the actual fossils. Arkell and Moy-Thomas (1940) have clearly pointed out the great harm done by this type of work.

Awaiting a revision of the Eodiscida based on proper study of the material, the writer considers it preferable at least temporarily not to use any of the new genera made by Kobayashi, although some of them will prove to be valid.

Family Pagetiidae Kobayashi
Genus Pagetides Rasetti, 1945
Pagetides elegans Rasetti
Plate 1, figures 1–7

Pagetides elegans Rasetti, 1945, Am. Jour. Sci., vol. 243, p. 313, pl. 1, figs. 15–18.

Additional information about the characters of this trilobite and its stratigraphic and geographic distribution is available.

The types are from the boulders in the Ville Guay conglomerate. The species was later collected by the writer from Vermont and New York, and one specimen from the Parker shale is interesting becase it shows the complete thorax, which has three segments. Since *Pagetia* has two thoracic segments, there is added an important distinctive character. The specimens from Vermont and New York are poorly preserved but agree with the types as far as can be ascertained. The test in the specimens from the Parker shale is lacking, being represented only by limonite stains. Artificial metal casts of natural molds show the characters of the species much more clearly than actual specimens in relief, and were used for the photographs.

Holotype and paratypes: Laval University nos. 304 a–c. From boulder L-11, Ville Guay, Quebec.

Plesiotypes: Laval University nos. 315a-c. From the Parker shale, *Olenellus* zone; Kelly quarry, ½ mile east of Swanton Junction, Vermont. Plesiotype: Laval University no. 316. From the Schodack formation; thin-bedded limestone on west side of Route 286, 3.7 miles north of Middle Granville, Washington County, New York.

PAGETIDES AMPLIFRONS Rasetti
Plate 1, figures 8, 9

Pagetides amplifrons RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 314, pl. 1, figs. 1–6.

This and the two following species are recorded for the sake of completeness.

Boulders 0–20, Island of Orléans and L-2, Ville Guay.

Holotype and paratypes: Laval University nos. 300 a-f.

PAGETIDES LEIOPYGUS Rasetti
Plate 1, figures 10–12

Pagetides leiopygus RASETTI, 1945, Am. Jour. Sci. vol. 243, p. 314, pl. 1, figs. 7–10.

Boulders L-2 and O-20, Island of Orléans and Ville Guay.

Holotype and paratypes: Laval University nos. 301 a-f.

PAGETIDES MINUTUS Rasetti
Plate 1, figures 13, 14

Pagetides minutus RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 313, pl. 1, figs. 11, 12.

Boulder 0–1, Island of Orléans.

Holotype and paratypes: Laval University nos. 302 a-b.

PAGETIDES RUPESTRIS Rasetti, n. sp.
Plate 1, figures 15–21

Known from numerous associated cranidia and pygidia.

Glabella subcylindrical, faintly furrowed at the sides, occupying slightly more than half the length of the head. Posterior portion of glabella and occipital ring fused to form a strong, laterally compressed, almost vertical spine. Area in front of the glabella depressed. Border very wide mesially and rapidly tapering in width at the sides. Radial impressions on border rather indistinct. Fixed cheeks as wide as the glabella and almost as high, convex. Palpebral lobes of average length, narrow, straight, separated by a narrow, well-impressed palpebral furrow. Ocular ridges indistinct. Facial sutures directed straight to the margin both in front of and behind the palpebral lobes, better visible in side view on account of the almost vertical slope of the sides of the cephalon.

Pygidium slightly wider than long, subtriangular, well rounded posteriorly. Axis narrow, elevated above the pleural lobes, almost reaching the posterior margin, composed of seven segments of which the last are poorly defined. Axial furrows better impressed at the sides than on the median line. Pleural lobes strongly convex, unfurrowed except for the anterior marginal furrow. Border extremely narrow but distinct all around.

Length and width of largest cranidium 4 mm., length of largest pygidium 4.0 mm., width 4.4 mm.

This species closely resembles *P. amplifrons*, from which it differs chiefly in the proportionately wider cranidium, upright occipital spine, and different character of the axial furrows of the pygidium.

Boulder G-24, Grosses Roches.

Holotype and paratypes: Laval University nos. 317 a-f.

Genus PAGETIA Walcott, 1916

The writer described two species of the genus from the Ville Guay conglomerate, *P. ellsi* and *P. billingsi*. These trilobites were then considered Lower Cambrian because the faunas from the locality had not been

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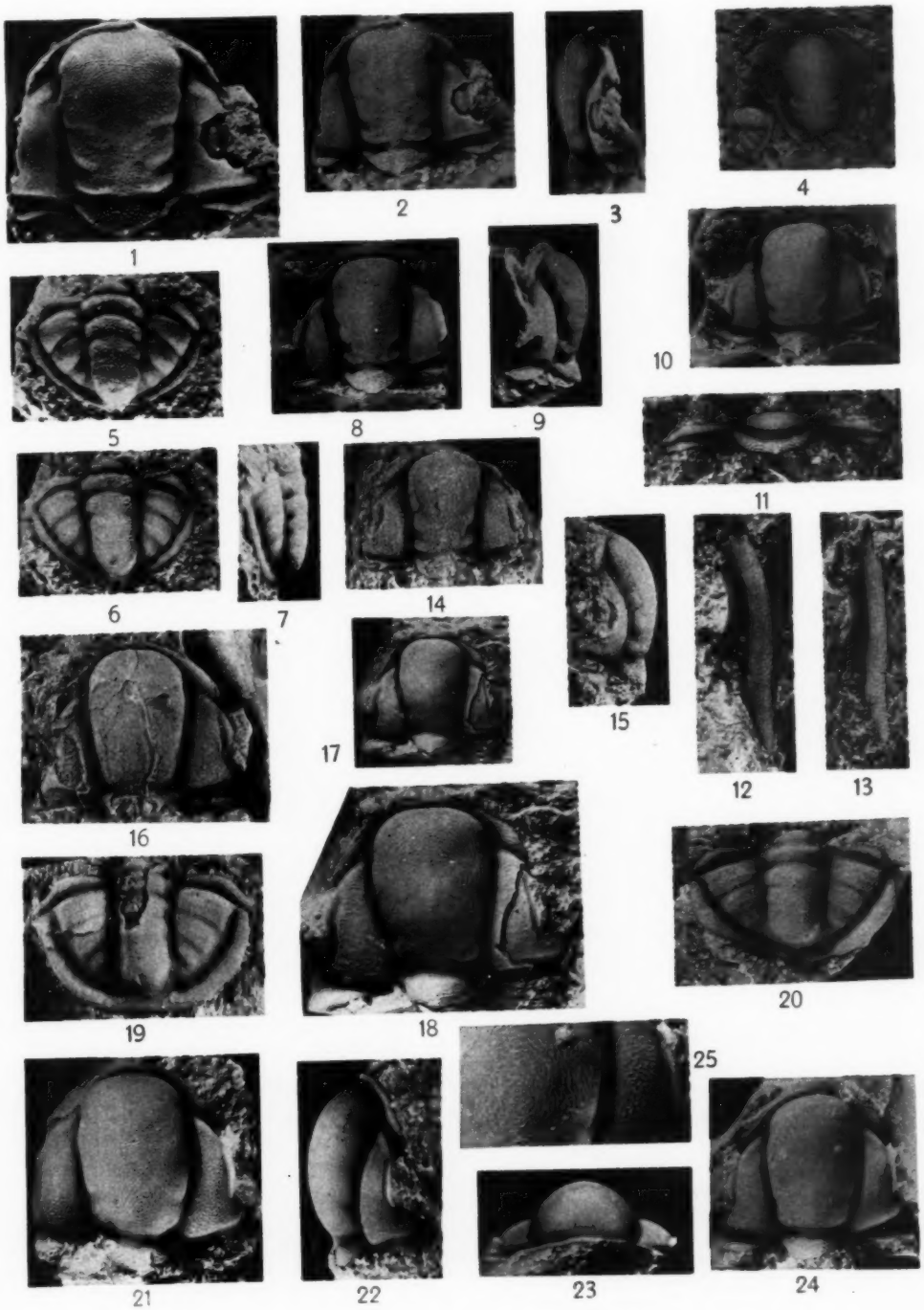
EXPLANATION OF PLATE 3

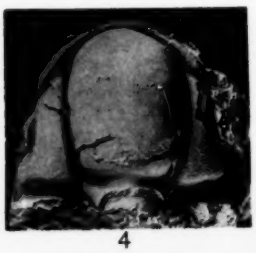
The test is preserved in all the figured specimens unless otherwise indicated.
All the figured fossils are from the conglomerates of the lower St. Lawrence valley.

FIGS. *1–15*—*Bonnia bicensis* Resser. *14, 15*, Top and side views of cranidium, ×4; USNM 62735, holotype. *1*, Cranidium, ×4, photographed with special lighting to show the surface ornamentation. *2, 3*, Top and side views of the same cranidium, ×3. *4*, Hypostoma, ×5. *5, 6*, Two photographs of pygidium, ×4, the first with special lighting to show the surface ornamentation. *7*, Side view of same pygidium. *8, 9*, Top and side views of another cranidium, ×3. *10*, Another cranidium, ×3. *11*, Thoracic segment, ×5. *12, 13*, Free cheeks, ×5, Laval U. 321a–h, plesiotypes. (p. 15)

16–25—*Bonnia brennus* (Walcott). *16*, Cranidium, ×4; USNM 62748, holotype. *17, 18*, Another cranidium, ×3 and ×5. *19, 20*, Pygidia, ×3. *21–23*, Top, side and front views of cranidium. ×4. *24*, Another cranidium, ×4. *25*, Portion of surface of same cranidium, ×8; Laval U. 322a–f, plesiotypes. (p. 16)



Rasetti, Lower Cambrian Trilobites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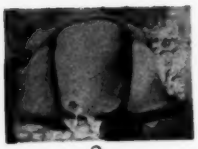
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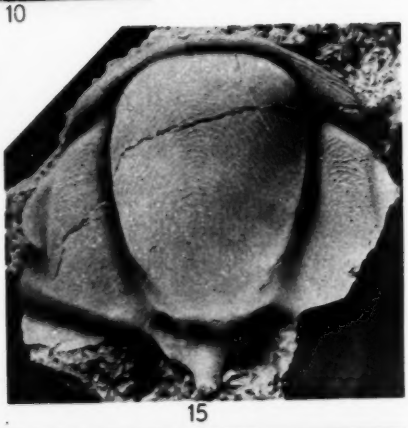
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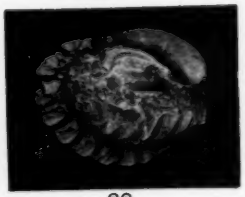
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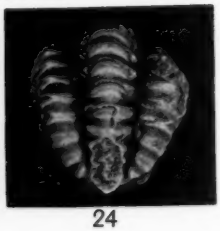
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Rasetti, Lower Cambrian Trilobites

completely studied and it was believed that only Lower Cambrian boulders were present. Further study has shown that there are two faunal assemblages, one Lower Cambrian and one early Middle Cambrian, and that the two species of *Pagetia* belong to the latter.

However, the presence of *Pagetia* in Lower Cambrian strata is confirmed by the discovery that a species described by Walcott from the Schodack formation and considered by him as a blind eodiscid actually has eyes and free cheeks, and must be referred to *Pagetia*. This species does not occur in the conglomerates of Quebec; however, it is discussed below because of its relationship with some of the species from Quebec, and is figured in order to show the features that were missed by Walcott.

PAGETIA CONNEXA (Walcott)
Plate 1, figures 22–27

Microdiscus connexus WALCOTT, 1887, Am. Jour. Sci., 3rd ser., vol. 34, p. 194, pl. 1, figs. 4–4b.
Eodiscus connexus (Walcott). RAYMOND, 1913, Ottawa Nat., vol. 27, p. 103.
Spinodiscus connexus (Walcott). KOBAYASHI 1943, Imp. Acad. Tokyo Proc., vol. 19, p. 39.

Walcott described and figured this species as blind, representing the border of the head as continuous. However, examination of the types and of additional material collected by the writer from the typical locality shows that the border is invariably interrupted where the free cheeks are missing. The palpebral lobes are clearly visible, and even ocular ridges can be distinguished under proper lighting. These features are clearly shown by the accompanying illustrations.

Another feature that was missed by Walcott is the long, slender terminal spine on the pygidial axis. This character is common to all known species of *Pagetia*.

Cranidium and pygidium entirely agree with those of the western Middle Cambrian species of the genus. The only significant difference might reside in the number of thoracic segments, which in the present species is unknown. If this number were three instead of two the species should be referred to *Pagetides*, but all the cranidial and pygidial features rather indicate *Pagetia*.

Kobayashi (1943) revised this species without studying the material, hence he missed the presence of eyes and placed the species in a genus of blind Eodiscida.

Schodack formation: thin-bedded limestone on the south side of U. S. 4, about ¼ mile west of the bridge on the Poultney River, near Low Hampton, Washington County, New York.

Syntypes: USNM no. 17449. Plesiotypes: Laval University nos. 318 a-f.

ORDER OPISTHOPARIA
Superfamily BATHYURISCIDEA Richter
Family DORYPYGIDAE Kobayashi

The genera *Bonnia*, *Bonniella*, *Kootenia*, *Dorypyge*, *Olenoides*, and possibly *Bonnaspis* and *Holteria*, form a very homogeneous assemblage for which the name Dorypygidae seems best indicated. This name was proposed by Kobayashi as a subfamily of the Oryctocephalidae, with which some of these genera have long been associated notwithstanding the only distant relationship.

Resser proposed the name Kootenidae for the family but Kobayashi's name has priority.

EXPLANATION OF PLATE 4

The test is preserved in all the figured specimens unless otherwise indicated.
All the figured fossils are from the conglomerates of the lower St. Lawrence valley.

FIGS. *1–6—Bonnia brennoides* Rasetti, n. sp. *1*, Front view of cranidium, ×3. *2, 3*, Top and side views of the same cranidium, ×2; Laval U. 323a, holotype. *4*, Larger cranidium, ×2. *5, 6*, Pygidia, ×2; Laval U. 323b–d, paratypes. (p. 16)
7–10—Bonnia similis Rasetti, n. sp., ×3. *7, 8*, Top and side views of cranidium; Laval U. 324a, holotype. *9*, Another cranidium. *10*, Pygidium; Laval U. 324b–c, paratypes. (p. 17)
11–15—Bonnia occipitalis Rasetti, n. sp. *11*, Partly exfoliated pygidium, ×3. *12*, Cranidium, ×3; Laval U. 325a–b, paratypes. *13, 14*, Side and top views of cranidium, ×2.5; Geol. Surv. Canada 9486, holotype. *15*, Holotype cranidium, ×5. (p. 17)
16–24—Bonnia bubaris (Walcott), ×2.5. *16, 17*, Top and side views of cranidium. *18*, Slightly distorted cranidium. *19*, Pygidium; Laval U. 327a–c, plesiotypes. *20, 21*, Side and top views of cranidium; USNM 62734, holotype. *22–24*, Lateral, cranidial and pygidial views of enrolled, exfoliated specimen; USNM 62734, paratype. (p. 17)

Genus KOOTENIA Walcott, 1889

KOOTENIA cf. K. MARCOUI (Whitfield)

Plate 2, figure 7

Dikellocephalus ? marcoui WHITFIELD, 1884, Am. Mus. Nat. Hist. Bull., vol. 1, p. 150, pl. 14, fig. 7.

Olenoides marcoui (Whitfield). WALCOTT, 1886, U. S. Geol. Surv. Bull. 30, p. 186, pl. 26, figs. 5–5b.

Dorypyge marcoui (Whitfield). MATTHEW, 1897, Roy. Soc. Canada Trans., 2nd ser., vol. 3, sect. 4, p. 187.

Kootenia marcoui (Whitfield). RESSER, 1937, Smithsonian Misc. Coll., vol. 95, no. 22, p. 16.

Pygidia of a species of *Kootenia* occur in several of the Lower Cambrian boulders, usually in association with *Periommella yorkensis* and *Pagetides*. Well-preserved cranidia could not be recovered, hence the specific identity with Whitfield's species or with one of those described by Resser from the southern Appalachians is doubtful.

The pygidium has seven pairs of marginal spines, and this character easily distinguishes it from the numerous Middle Cambrian species from the same conglomerates; these never have more than six pairs of spines. The first three axial segments have nodes, which are broken off and might have been spines. The surface of the test is finely granulose.

Figured specimen (from boulder G-24, Grosses Roches): Laval University no. 319.

Genus BONNIA Walcott, 1916

Whenever the Lower Cambrian of the Appalachian and Cordilleran provinces is represented by a limestone facies, *Bonnia* is generally the most prolific trilobite both in numbers of species and individuals. The unusually thick test of this trilobite favors its good preservation.

The boulders in the St. Lawrence valley have already supplied several species, and more are here described. Usually each boulder contains only one species, represented by large numbers of cranidia and pygidia, thus affording an unquestionable assignment of the two shields to one species.

The material collected by the writer was compared with the types of the species described by Billings, Walcott and Resser, many of which can now be more completely described and better understood.

In most cases, the species from Quebec seem to be distinct from those described from Labrador. Comparison with the forms from Vermont and Pennsylvania is difficult, because these are usually preserved in leached dolomite or shale and lack the test, whereas several of the species here discussed can be distinguished only by the characteristic surface ornamentation. In these doubtful cases the species from Quebec are described as new.

The species included in *Bonnia* vary to a considerable extent in the shape of the glabella, distinctness of the glabellar furrows, depth of the dorsal furrow, presence or absence of an occipital spine, and other features. However, distant species are well linked by a series of intermediate forms and there seeems to be no reason for splitting the genus. The pygidia are far more uniform and more diagnostic for the genus than the cranidia, since isolated cranidia can hardly be distinguished from *Kootenia*.

A brief revision of the species of this genus was recently given by Lochman (1947). Her conclusions agree with the writer's regarding all the species here discussed.

BONNIA BUSA (Walcott)

Plate 6, figures 18–20

Corynexochus (*Bonnia*) *busa* WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 326, pl. 57, fig. 1a; pl. 60, figs. 3–3c.

Bonnia busa (Walcott). RESSER, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 7.

This is the only species known from the conglomerates of Quebec which shares with the genotype, *B. parvula* (Billings), the parallel-sided glabella and the deep anterior marginal furrow separating a wide border. These characters, coupled with the presence of glabellar furrows, separate it from all other known species.

The writer has been unable to collect this species, which is thus known only from Walcott's types.

Bic (boulder unknown).

Lectotype and paratype: USNM nos. 62773-4.

BONNIA SENECTA (Billings)

Plate 5, figures 5–7

Bathyurus senectus BILLINGS, 1865, Geol. Surv. Canada, Palaeozoic Fossils, vol. 1, p. 15, figs. 19, 20.

Protypus senectus (Billings). WALCOTT, 1886, U. S. Geol. Surv. Bull. 30, p. 213, pl. 31, figs. 2–2c.
Bathyuriscus senectus (Billings). MATTHEW, 1897, Roy. Soc. Canada Trans., vol. 3, sect. 4, p. 196, pl. 4, figs. 4, 4a.
Corynexochus senectus (Billings). WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 319 (figures refer to other species).
Bonnia senecta (Billings). RESSER, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 8; 1937, Jour. Paleontology, vol. 11, p. 47, pl. 8, figs. 20–22.

Resser showed that Billings' type from Labrador is the only specimen belonging to the species, and assigned to other forms all the material that Walcott had identified as *B. senecta*.

Among the hundreds of individuals of *Bonnia* collected from the conglomerates, only a few from a single boulder can be assigned to Billings' species after careful comparison with the holotype.

B. senecta is characterized by a proportionately narrower glabella and wider fixed cheeks than any other species known to the writer. Its strong surface ornamentation described by Resser and clearly shown in the accompanying illustrations, and the relatively deep glabellar furrows, are other characters that distinguish it from similar species.

The occipital ring is broken off in all the cranidia observed, but it appears likely that it had a spine.

The pygidium is characterized by a relatively narrow border, showing a pair of small spines at the anterior angles, and a slight expansion where a second pair of spines is situated in other species. The pleural lobes show four or five distinct pairs of furrows. The surface of the elevated parts is granulated.

Neoholotype (from Anse au Loup, Labrador): Geol. Surv. Canada no. 420. Plesiotypes (from boulder G-27, Grosses Roches): Laval University nos. 320 a-b.

BONNIA BICENSIS Resser
Plate 3, figures 1–15

Corynexochus bubaris WALCOTT (part), 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 314, pl. 56, fig. 2a (only).
Bonnia bicensis RESSER, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 10.

This species was based by Resser on two cranidia separated from Walcott's lot of specimens of *Corynexochus bubaris*. The published description and illustration give no adequate idea of this species, but comparison with the type shows that *B. bicensis* is one of the species represented in the author's collections by hundreds of fragments. This is probably the best represented of all species of *Bonnia*, hence a detailed description of all parts of the carapace will be given.

Glabella on the average expanding forward, almost straight-sided, presenting a slight constriction in front of the anterior pits, which are well impressed. Dorsal furrow deep. Posterior glabellar furrows relatively deep, short, oblique. Another pair short, shallow, transverse; there is just an indication of a third pair. Longitudinal convexity of the glabella greater anteriorly. Occipital furrow deep laterally, somewhat shallower mesially. Occipital ring triangular, somewhat elevated, forming a short spine. Border in front of the glabella narrow. Brim reduced to a pair of narrow depressions at the sides, between the border and the ocular ridges; the latter wide and low. Fixed cheeks one-half the glabellar width. Palpebral lobes moderately curved, one-third the length of the glabella; palpebral furrows shallow. Posterior limbs rather short, rounded, deeply furrowed. Free cheeks very narrow, the pleural platforms being greatly reduced. Border wide, convex, extending into a moderately long genal spine.

Hypostoma rather convex. Anterior and posterior lobes separated only at the sides by a pair of oblique furrows that do not greatly diverge from the marginal furrow. Maculae rather prominent. Anterior wings sharply pointed. Lateral and posterior border well developed; lateral border forming a pair of very short spines situated somewhat in advance of the maculae.

Thoracic segments with a prominent axis; a small node on each axial ring. Pleura flat for the proximal two-thirds of the length, rather sharply bent downward at geniculation. Furrows fairly deep, narrower distally.

Pygidium with a strongly prominent, slightly tapered axis that almost reaches the posterior margin. A postaxial ridge interrupts the marginal furrow and reaches the margin. Axis with three furrows and a terminal un-

segmented section. Pleural platforms convex, with three shallow furrows. Border of average width, with the anterior spine well developed and a small, rounded second pair.

Surface of glabella with irregular transverse ridges on anterior portion, breaking into separate granules posteriorly. Occipital segment with larger granules. Fixed cheeks with fainter granules. Thoracic axial segments and pygidial axis strongly granulated.

Length of largest cranidium 8 mm.

This species is close to *B. senecta*, from which it differs in the wider glabella and pygidial axis, smaller number of segments in the pygidium, and less strong surface ornamentation.

Holotype (from Bic, boulder unknown): USNM no. 62735. Plesiotypes (from Bic, boulder B-9); Laval University nos. 321 a-h.

BONNIA BRENNUS (Walcott)
Plate 3, figures 16–25

Corynexochus brennus WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 314, pl. 57, figs. 3–3b.

Corynexochus bubaris WALCOTT (part), 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 314, pl. 56, fig. 2b (only).

Bonnia brennus (Walcott). RESSER, 1946, Smithsonian Misc. Coll., vol. 95, no. 4, p. 7.

Bonnia quebecensis RESSER, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 10.

This is one of the common species at Bic and other localities, being represented in the writer's collections by large numbers of cranidia and pygidia.

Glabella expanding toward the front, attaining its maximum width somewhat behind the ocular ridges, slightly constricted in front of the anterior pits. Glabella rather strongly and uniformly convex both transversely and longitudinally. Posterior glabellar furrows short and very shallow; other furrows indistinct. Occipital furrow deep, somewhat shallower mesially. Occipital ring rather narrow, widened mesially, rounded, elevated, in some of the specimens showing an incipient occipital spine. Border in front of the glabella very narrow, strongly curved; at the sides strongly inclined backward. Brim reduced to a very narrow depression between the border and the ocular ridges. Ocular ridges wide, weakly elevated. Fixed cheeks two-fifths the width of the glabella at the level of the palpebral lobes, moderately convex, on the average sloping downward. Palpebral lobes slightly more than one-third the glabellar length, almost straight, narrow; palpebral furrow straight, rather well impressed. Posterior limbs short, with a deep, wide furrow.

Pygidium about 1.4 times wider than long. Axis cylindrical, strongly convex, rounded posteriorly, reaching the marginal furrow. Three segments and a terminal unsegmented section are separated by increasingly shallow furrows. Pleural lobes convex, with a deep anterior marginal furrow and two or three other rather indistinct furrows. Border rather wide, convex, set off by a distinct marginal furrow. Only one pair of marginal spines at the anterior angles.

Surface of glabella with irregular concentric ridges. Surface of anterior border striated, of fixed cheeks granulated. Surface of prominent areas of pygidium granulated.

Length of largest cranidium observed 10 mm.

This species chiefly differs from *B. senecta* and *B. bicensis* in the shallowness of the glabellar furrows, narrower fixed cheeks, different surface ornamentation, lack of a well-developed occipital spine, and almost obsolete pleural furrows on the pygidium.

Holotype and paratypes (from Bic, boulder unknown): USNM nos. 62748-50. Plesiotypes (from Bic, boulders B-5 and B-11): Laval University nos. 322 a-f.

BONNIA BRENNOIDES Rasetti, n. sp.
Plate 4, figures 1-6

Known from numerous cranidia and associated pygidia. This species is so similar to *B. brennus* that it seems useless to repeat a complete description; only those features in which the two species differ will be mentioned. The chief difference is the lesser depth of the dorsal furrow in the new species; as a consequence, the fixed cheeks slope more definitely downward. The occipital ring is of more uniform width and less elevated than in *B. brennus*. The surface ornamentation does not differ in the two species. The pygidia are practically indistinguishable.

This is the largest species of the genus known to the writer, the largest cranidium having a length of 13 mm.

Boulder G-9, Grosses Roches.

Holotype and paratypes: Laval University nos. 323 a-h.

BONNIA SIMILIS Rasetti, n. sp.
Plate 4, figures 7-10

Known from numerous cranidia and associated pygidia.

This is another species that closely resembles *B. brennus* and may be described by pointing out the differences. The glabella has about the same outline as in *B. brennus*, but its longitudinal convexity is more concentrated in its frontal portion. The occipital ring has a somewhat more even width. The depression between the border and the ocular ridges is shallower. The palpebral lobes are proportionately shorter, more obliquely directed, and have a more anterior position. The posterior limbs are somewhat wider.

The pygidium has the same shape as in *B. brennus*.

The cranidium of this species entirely lacks surface ornamentation. The elevated areas of the pygidium show faint granules in some of the specimens.

Length of the largest cranidium 10 mm.

Boulder O-25, Island of Orléans.

Holotype and paratypes: Laval University nos. 324 a-k.

BONNIA OCCIPITALIS Rasetti, n. sp.
Plate 4, figures 11–15

Known from several cranidia and associated pygidia.

This is another species that may be described by pointing out the characters that distinguish it from *B. brennus*. The glabella has the same convexity as in that species, but expands more strongly forward, being more pear-shaped. The posterior glabellar furrows are more deeply impressed. The occipital ring extends into a slender, rather long, upturned occipital spine. The palpebral lobes are somewhat wider and have a more curved outline than in *B. brennus*.

The pygidium differs considerably from that of *B. brennus* in that the axis occupies only one-fourth instead of one-third of the total width. There is one pair of marginal spines.

Surface ornamentation represented by irregular concentric ridges on glabella, transverse ridges on anterior border, and granules on fixed cheeks. The surface of the pygidium is almost smooth.

The pear-shaped glabella, occipital spine, and characteristic surface ornamentation distinguish this from all other known species.

Length of largest cranidium 9 mm.

Holotype and paratype (from Bic, boulder unknown): Geol. Surv. Canada nos. 9486, 9486a-b. Paratypes (from Bic, boulder B-14): Laval University nos. 325 a-b.

BONNIA SCULPTA Rasetti, n. sp.
Plate 5, figures 1–4

Known from several cranidia and associated pygidia.

This species is very close to *B. occipitalis* and may be described by listing the differences. The glabella has the same general shape and convexity, but is more definitely constricted in front of the anterior pits which are deeply impressed. The glabellar furrows are strong for the genus; posterior pair deep, oblique, another pair very short, transverse, rather well impressed, third pair indistinct. Occipital spine as in preceding species. Palpebral lobes as in *B. occipitalis*.

Pygidium of the same shape as in the preceding species; axis occupying one-fourth of the width. Axial furrows somewhat better impressed, up to four furrows visible on the upper surface. Four pleural furrows are distinct. Border of average width, with marginal spine only at anterior angles.

Surface ornamentation of cranidium of the same pattern as in preceding species, but much stronger; pygidium with scattered granules.

Length of largest cranidium 6 mm.

Boulders G-17 and G-41, Grosses Roches.

Holotype (from boulder G-17) and paratypes: Laval University nos. 326 a-j.

BONNIA BUBARIS (Walcott)
Plate 4, figures 16–24

Corynexochus bubaris WALCOTT (part), 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 314, pl. 56, fig. 2 (only).

Bonnia bubaris (Walcott). RESSER, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 10.

Walcott based *C. bubaris* on material from several localities which was separated by Resser into five different species. A new

description of the species as now restricted is required.

Glabella strongly convex in both directions, the longitudinal convexity being greater anteriorly. Glabella moderately expanding forward, almost straight-sided, with shallow but distinct posterior furrows and a trace of two other pairs. Border in front of the glabella very narrow. Occipital furrow deep; occipital ring with a slender upturned spine. Brim somewhat more developed at the sides than in *B. bicensis* and *B. brennus*, owing to the greater distance between the border and the ocular ridges. Fixed cheeks, palpebral lobes and posterior limbs as in *B. brennus*.

Pygidium with a relatively narrow, tapered axis that does not quite reach the marginal furrow, but is continued by a postaxial ridge that joins the border. Axis composed of three segments plus a terminal section, separated by increasingly shallow furrows. Pleural lobes with four wide, shallow furrows and as many distinct interpleural grooves. Border rather narrow, with two pairs of short spines.

The surface of the glabella is covered with fine granules, the spaces between the granules being punctate. The pygidium is also finely granulated.

Among Walcott's specimens from the typical locality is a complete enrolled individual, the only complete shield of *Bonnia* ever described. The thorax has eight segments.

Length of largest cranidium observed 11 mm.

This species differs from *B. bicensis* in the shallower glabellar furrows, longer occipital spine, different surface ornamentation and considerably different pygidium. From *B. brennus* it can be readily separated by the straight-sided glabella, occipital spine, different surface ornamentation and many differences in the pygidium.

Holotype and paratypes (from Bic, boulder unknown): USNM no. 62734. Plesiotypes (from Bic, boulder B-10); Laval University nos. 327 a-c.

Bonnia crassa Resser
Plate 5, figures 15–20

Bonnia crassa Resser, 1938, Geol. Soc. America Special Papers, 15, p. 66, pl. 3, figs. 43–45.

Resser's exceedingly brief description of this species is insufficient to characterize it. One of the species from the conglomerates, represented by large numbers of cranidia and pygidia, was carefully compared with the types, and appears entirely to agree with them.

Glabella straight-sided, slightly expanded forward, moderately convex transversely and longitudinally; longitudinal convexity greater anteriorly. Glabellar furrows very faint, almost indistinct. Occipital furrow well impressed especially at the sides. Occipital ring rather wide mesially, rounded in outline, with a small node. Border in front of the glabella very narrow. Brim reduced to a narrow depression between the border and the ocular ridges. Fixed cheeks, palpebral lobes and posterior limbs as in *B. bicensis*.

Pygidium with axis occupying almost one-third of the width, slightly tapered, showing two very shallow furrows and a terminal section. Pleural lobes with only a trace of segmentation besides the anterior marginal furrow. Border fairly wide, separated by an indistinct marginal furrow. Only one pair of marginal spines at the anterior angles.

Surface of both shields smooth except for weak transverse ridges on the anterior half of the glabella, and granules on the occipital segment.

Length of largest cranidium 7 mm.

This species resembles *B. bicensis* in general shape, but all the furrows are shallower, and the occipital segment does not form a triangular spine. The surface ornamentation is much less distinct and limited to a smaller area.

Holotype and paratypes (from the Shady formation at Austinville, Virginia): USNM no. 94757. Plesiotypes (from boulder B-2, Bic and boulder G-21, Grosses Roches): Laval University nos. 328 a-d.

Bonnia tensa Resser
Plate 5, figures 21–28

Bonnia tensa Resser, 1938, Geol. Soc. America Special Papers, 15, p. 66, pl. 3, fig. 46.

Resser's very short description is insufficient to characterize the species. Large numbers of cranidia and pygidia recovered from some of the boulders agree with the type.

Glabella weakly convex, delimited by a very shallow dorsal furrow, straight-sided,

moderately expanded toward the front. Occipital furrow shallow mesially, fairly deep at the sides. Occipital ring rounded, of medium width. Glabellar furrows indistinct. Anterior pits rather deep, made more conspicuous by the shallowness of the dorsal furrow. Anterior border reduced to an extremely narrow strip in front of the glabella. Brim at the sides limited to a very small area. Ocular ridges indistinct. Palpebral lobes about one-third the glabellar length, narrow, set off by very shallow palpebral furrows. Posterior end of the palpebral lobes on a line through the posterior sixth of the glabella. Posterior limbs correspondingly narrow, somewhat narrower than in *B. crassa* which in turn has slightly narrower posterior limbs than *B. bicensis*.

Pygidium with a cylindrical axis showing a shallow furrow and traces of two more. Axis fairly elevated above the pleural lobes. Pleural lobes moderately convex, with the anterior furrow shallow and the others indistinct. Border delimited by a very shallow, poorly defined marginal furrow. A small pair of spines at the anterior angles.

Surface smooth except for indistinct ridges on the anterior portion of the glabella.

Length of largest cranidium 7 mm.

This species is obviously very closely related to *B. crassa*, from which it differs in the lesser convexity of the glabella, shallowness of all furrows, and the great reduction of the anterior cephalic border. A very similar species is *B. fieldensis* (Walcott) from the Mt. Whyte formation of British Columbia. *B. tensa* can readily be separated from *B. fieldensis* by the more posterior position of the palpebral lobes and the corresponding narrowness of the posterior limbs. The next species to be described, *B. laevigata*, represents a further step toward the obliteration of all furrows, at least on the outer surface.

Holotype (from the Shady formation of Virginia): USNM no. 94758. Plesiotypes (from boulder G-25, Grosses Roches): Laval University nos. 329 a-e.

BONNIA LAEVIGATA Rasetti, n. sp.
Plate 5, figures 8–14

Known from numerous cranidia and pygidia collected from several boulders.

Glabella poorly defined on the outer surface by an exceedingly shallow dorsal furrow, but well delimited on the cast of the inner surface; straight-sided, expanding rather rapidly toward the front, unfurrowed. Occipital furrow almost obsolete mesially but well impressed at the sides. Occipital ring somewhat expanded mesially, rounded in outline. Border in front of the glabella absent. Ocular ridges indistinct. Palpebral lobes of average length, separated by a very shallow palpebral furrow. Posterior limbs short, wide, rounded, with a wide marginal furrow. Free cheeks very narrow.

Pygidium showing just a trace of the outline of the axis on the upper surface, lacking axial, pleural and marginal furrows. On the cast of the interior the dorsal furrows are fairly deep, and four axial and pleural furrows are visible. The very thick test of the trilobites of this genus makes possible this great difference in the depth of the furrows on the outer and inner surfaces. One pair of short spines at the anterior angles.

Surface entirely smooth except for a few transverse ridges on the anterior edge of the glabella.

Length of largest cranidium 9 mm.

This species can be readily distinguished from all others described by the shallowness of all furrows on the outer surface and by the indistinct frontal border. The closest described species is *B. fieldensis* from the Mt. Whyte formation of British Columbia.

Holotype (from boulder G-41, Grosses Roches): Laval University no. 330 a. Paratypes (from boulders G-41, Grosses Roches; B-1, Bic; and M-10, Métis): Laval University nos. 330 b-o.

Family BATHYURISCIDAE Richter

Besides the type genus, the genera *Anoria*, *Athabaskia*, *Clavaspidella*, *Dolichometopsis*, *Glossopleura*, *Klotziella*, *Orria*, *Poliella* and *Ptarmigania* may be included in the family Bathyuriscidae. This assemblage approximately corresponds to Raymond's subfamily Dolichometopinae, but since the close relationship of all these trilobites with the Atlantic province genus *Dolichometopus* is doubtful, the writer prefers using a family name based on a genus from the Cordilleran province. All these genera are linked by intermediate forms. It is also difficult to trace a sharp limit between this group and

such related genera as *Albertella*, *Prozacanthoides* and *Zacanthoides*, which may be separated on the basis of the longer eyes and greater tendency to develop spines on all parts of the shield.

The family Ptarmiganidae, proposed by Resser, does not seem necessary as its type genus is closely related to *Bathyuriscus*.

Genus DOLICHOMETOPSIS Poulsen, 1927

Poulsen described the genotype, *D. resseri*, and other species from the Lower Cambrian of northwest Greenland. The type species is primarily based on cranidia, but Poulsen tentatively assigned to it a small pygidium. Later Resser assigned to the genus many species from the Middle Cambrian of Idaho. These forms are characterized by a large, spinose, *Kootenia*-like pygidium. Resser concluded that Poulsen had assigned a wrong pygidium to his cranidia, and modified the diagnosis of the genus accordingly.

In the writer's opinion, Resser's action is unwarranted. It is not obvious that similar cranidia from the Lower Cambrian of Greenland and the Middle Cambrian of Idaho possess pygidia of the same type. It is more plausible to assume that Poulsen's assignment of the pygidium is correct. In this case, a new genus will be required for Resser's species, unless they can be included in *Ptarmigania*.

Two species from Bic are tentatively assigned to *Dolichometopsis*. The cranidia agree, but too little is known of the pygidia to make the identification reasonably certain.

DOLICHOMETOPSIS? MINOR Rasetti, n. sp.
Plate 2, figures 12–16

Known from numerous cranidia and one entire shield.

Glabella straight-sided, moderately expanded forward, strongly convex transversely and also longitudinally in the anterior part. Posterior glabellar furrows oblique, in some specimens almost united across the glabella. One or two other pairs very shallow. Occipital furrow well impressed; occipital ring triangular, forming a blunt spine. Border in front of the glabella very narrow, almost wanting mesially. Brim and border developed at the sides of the glabella. Fixed cheeks about one-half the glabellar width; palpebral lobes somewhat less than one-half as long as the glabella, curved in their posterior half. Palpebral furrow and ocular ridge well developed. Posterior limbs of moderate length, narrow, strongly furrowed.

Thorax of eight segments in small complete shield. Entire thorax tapering rapidly in width after the fourth segment. Axis prominent. Pleura flat, curved backward. Pleural furrows wide, occupying the middle of each pleuron. There is a long, triangular tubercle on the proximal part of each pleuron as in several trilobites of this type.

Pygidium very small; axis with one segment and a terminal section. Pleural lobes with one or two furrows curving bakcward. The only pygidium known is so small that its precise shape cannot be clearly ascertained.

Surface of cranidium very finely granulated.

EXPLANATION OF PLATE 5

The test is preserved in all the figured specimens unless otherwise indicated.
All the figured fossils are from the conglomerates of the lower St. Lawrence valley.

FIGS. *1–4—Bonnia sculpta* Rasetti, n. sp. *1*, Cranidium, ×6. *2*, *3*, Top and side views of the same cranidium, ×3; Laval U. 326a, holotype. *4*, Pygidium, ×3; Laval U. 326b, paratype. (p. 17)

5–7—Bonnia senecta (Billings). *5*, Cranidium, ×4, photographed with special lighting to show the surface ornamentation. *6*, The same cranidium, ×3. *7*, Partly exfoliated pygidium, ×3; Laval U. 320a–b, plesiotypes. (p. 14)

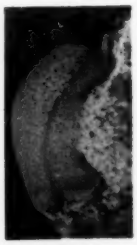
8–14—Bonnia laevigata Rasetti, n. sp., ×3. *8*, *9*, Top and side views of cranidium; Laval U. 330a, holotype. *10*, *11*, Top and side views of another cranidium. *12*, *13*, Partly exfoliated pygidia. *14*, Pygidium; Laval U. 330b–e, paratypes. (p. 19)

15–20—Bonnia crassa Resser, ×4. *15*, Partly exfoliated cranidium. *16*, *17*, Top and side views of another cranidium. *18*, *19*, Top and side views of pygidium. *20*, Another pygidium; Laval U. 328a–d, plesiotypes. (p. 18)

21–28—Bonnia tensa Resser, ×3. *21–24*, Top and side views of two cranidia. *25*, Pygidium. *26*, Hypostoma. *27*, *28*, Top and side views of pygidium; Laval U. 329a–d, plesiotypes. (p. 18)

Rasetti, Lower Cambrian Trilobites

1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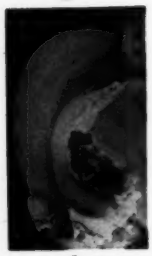
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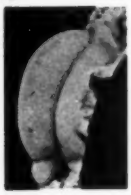
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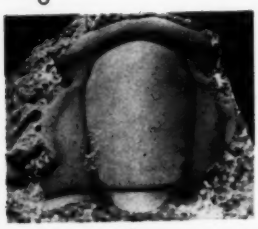
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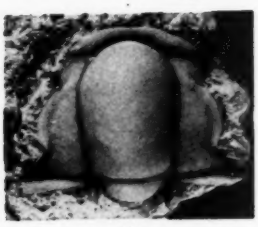
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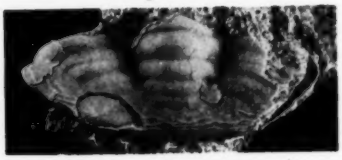
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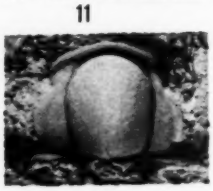
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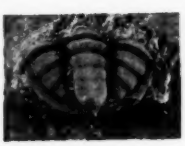
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19

Rasetti, Lower Cambrian Trilobites

Length of largest cranidium 4 mm. Length of complete shield 4.3 mm., of which 1.9 mm. belong to the head, 2.0 mm. to the thorax and 0.4 mm. to the pygidium.

Boulder B-14, Bic.

Holotype and paratypes: Laval University nos. 331 a-z.

DOLICHOMETOPSIS? BICENSIS Rasetti, n. sp.
Plate 2, figures 8–11

Known from several cranidia.

The cranidium of this species is so similar to that of *D ?.minor* that it may be described by indicating the differences. In *D ?.bicensis* the frontal border is quite distinct, while it is almost obsolete in the preceding species. The glabellar furrows are more deeply impressed, four pairs being distinguishable. In this as in many other bathyuriscid trilobites showing four pairs of glabellar furrows, the weakest is not the fourth but rather the third from the back.

This species attains a larger size than the preceding, the largest cranidium being 7 mm. long.

Boulders B-4 and B-6, Bic (holotype from the former).

Holotype and paratypes: Laval University nos. 332 a-f.

Family ZACANTHOIDIDAE Swinnerton
Genus ZACANTHOPSIS Resser, 1938
ZACANTHOPSIS VIRGINICA Resser
Plate 2, figures 17–19

Zacanthopsis virginica RESSER, 1938, Geol. Soc. America Special Papers, 15, p. 106, pl. 3, figs. 39, 48.

Cranidia of *Zacanthopsis* that occur in several boulders apparently can be identified with Resser's species.

Glabella cylindrical, very slightly expanded in the anterior half, strongly convex transversely but rather flat longitudinally except in front. Glabellar furrows very shallow, in some specimens indistinct. Occipital furrow shallow; occipital ring extended into a slender horizontal spine about half the glabellar length. Brim and border not sharply differentiated; border upturned, slightly convex near the edge. Fixed cheeks at their maximum width about as wide as the glabella, rising somewhat above the level of the dorsal furrow. Palpebral lobes about half the glabellar length, strongly curved in their posterior half, elevated above the fixed cheeks, separated by a narrow, deep palpebral furrow. Ocular ridges strong. Maximum width of the fixed cheeks on a transverse line through the posterior fourth of the glabella. Posterior limbs very narrow. Anterior branch of facial suture directed strongly outward, curving rather sharply inward at the marginal furrow. Surface finely granulated. Length of largest cranidium (exclusive of the spine) 9 mm.

This species was found to be somewhat variable in the depth of the glabellar furrows, width of the fixed cheeks, curvature of the palpebral lobes and other details. However, since no clear-cut forms could be separated and the variability has no stratigraphic significance, the various forms occurring the in same boulder, the writer found no reason for recognizing more than one species.

Holotype and paratypes (from the Shady formation of Virginia): USNM no. 94755.

Plesiotypes (from boulders G-15 and G-27, Grosses Roches and M-10, Métis): Laval University nos. 333 a-c.

EXPLANATION OF PLATE 6

The test is preserved in all the figured specimens unless otherwise indicated.
All the figured fossils are from the conglomerates of the lower St. Lawrence valley.

FIGS. *1–4—Protypus typicus* (Resser). *1–3*, Top, side, and front views of cranidium, ×2.5; USNM 94734, paratype. *4*, Exfoliated pygidium, ×4; USNM 94734, holotype. (p. 22)

5–13—Protypus marginatus Rasetti, n. sp. *5–7*, Top, side, and front views of cranidium, ×2.5; Laval U. 335a, holotype. *8*, *9*, *12*, Three cranidia showing variation in shape of glabella and width of border, ×5. *10*, *11*, Top and side views of another cranidium, ×5. *13*, Pygidium, ×3; Laval U. 335b–f, paratypes. (p. 23)

14–17—Protypus reticulatus Rasetti, n. sp. *14*, *15*, Top and side views of cranidium, ×2.5; Geol. Surv. Canada 9487, holotype. *16*, Surface of glabella of another specimen, ×6. *17*, Another cranidium, ×2.5; Geol. Surv. Canada 9487a–b, paratypes. (p. 23)

18–20—Bonnia busa (Walcott), ×3. *18*, *19*, Top and side views of cranidium; USNM 62773, holotype. *20*, Pygidium; USNM 62774, paratype. (p. 14)

Genus PROZACANTHOIDES Resser, 1937
PROZACANTHOIDES sp. undet.
Plate 2, figures 20–24

Cranidia and pygidia of *Prozacanthoides* occur in several boulders, and show slight differences that may indicate more than one species. However, the insufficient number of specimens and the uncertainty in the association of cranidia and pygidia makes it preferable not to attempt specific identification. Resser's species from Virginia are also based on a few specimens and it is doubtful whether they are all distinct. It will be better to postpone a revision of the genus until more material is available.

Figured specimens from boulders L-11, Ville Guay; B-4, Bic; SS-1, St. Simon; G-19, Grosses Roches. Laval University nos. 334 a-e.

Family undetermined
Genus PROTYPUS Walcott, 1886

Walcott based the genus on *Angelina hitchcocki* Hall from the Parker shale of Vermont. The type and only specimen ever found, a complete shield flattened in shale, is now lost, but several plaster casts are extant. Resser (1938) established the genus *Bicaspis* on a new species, *B. typica* from the conglomerate at Bic. A pygidium was chosen as the holotype and a cranidium tentatively assigned to the species.

In the writer's opinion, Resser correctly assigned these shields to the same trilobite, but failed to recognize the identity of *Bicaspis* with *Protypus*. Allowing for the different manner of preservation, there is no significant difference in the cranidial and pygidial features.

The cranidium of *Protypus* is much like that of *Bonnia*, but there is a great difference in the number of thoracic segments (*Bonnia* has 8 and *Protypus* 12) and in the relative size and shape of the pygidium. *Protypus* does not seem to be closely allied to any other known trilobite and probably should be placed in a family by itself.

A new diagnosis of the genus based on the complete shield of *Protypus hitchcocki* and on fragmentary material preserved in limestone follows.

Glabella convex, somewhat expanding forward, unfurrowed. Occipital furrow shallow, occipital ring narrow and simple. Brim lacking in front, reduced to narrow bands at the sides. Border convex. Fixed cheeks sloping down from the dorsal furrow. Palpebral lobes flat, of medium size, with a faint palpebral furrow. Posterior limbs short. Anterior branch of facial suture short, directed slightly outward. Posterior branch directed transversely behind the eye.

Thorax composed of twelve segments. Axis strongly convex, tapered. Pleural lobes flat; pleura broadly furrowed, not extended into spines.

Pygidium very short and wide. Axis prominent, tapered, with few segments. Pleural lobes weakly convex, furrowed. Border down-rolled, poorly defined.

PROTYPUS TYPICUS (Resser)
Plate 6, figures 1–4

Bicaspis typica RESSER, 1938, Geol. Soc. America Special Papers, 15, p. 62, pl. 2, figs. 19–22.

Resser gave a brief generic diagnosis and no specific description at all.

Glabella strongly convex in both directions, straight-sided, slightly expanding forwards. Occipital furrow exceedingly shallow on the outer surface; occipital ring very narrow. Brim reduced to short bands at the sides. Border weakly convex, poorly defined from the brim at the sides by the marginal furrow. Fixed cheeks down-sloping; their maximum width equalling one-half the glabellar width. Ocular ridges faint. Palpebral lobes somewhat less than half the glabellar length, flat, moderately curved; palpebral furrows almost indistinct. Posterior limbs short. Anterior branch of facial suture short, directed almost straight forward.

Pygidium almost three times wider than long. Axis occupying more than two-thirds of the pygidial length, rapidly tapered, composed of three fairly distinct segments; elevated anteriorly but depressed posteriorly. Pleural lobes with two pairs of shallow pleural furrows and two pairs of narrower interpleural grooves. A pair of blunt spines at the anterior angles. Posterior outline straight mesially or even slightly concave. Border not defined by a marginal furrow, downrolled.

Surface smooth, except for transverse ridges on the border of the pygidium.

Length of largest cranidium 12 mm. Length of holotype pygidium 3 mm., width 8.5 mm.

Holotype and paratypes (from Bic, boulder unknown): USNM no. 94734.

PROTYPUS MARGINATUS Rasetti, n. sp.
Plate 6, figures 5–13

Known from numerous cranidia.

Glabella unfurrowed, strongly convex transversely; longitudinal convexity strong in the anterior half, the front of the glabella sloping down vertically. Glabella pear-shaped, well rounded in front. Occipital furrow moderately impressed; occipital ring rather narrow, simple. Dorsal furrow moderately impressed. Border narrow, convex; brim developed only at the sides. Fixed cheeks sloping downward, almost flat; their maximum width about one-third the glabellar width. Palpebral lobes about half as long as the glabella, regularly curved, flat; palpebral furrow very shallow. Posterior limbs narrow, almost parallel-sided, furrowed. Anterior branch of facial suture short, diverging outward, curving inward after crossing the marginal furrow. Posterior branch directed almost transversely behind the palpebral lobe, then curving backward. Surface of test smooth.

A pygidium associated with the cranidia and tentatively referred to the species is almost identical with the pygidium of *P. typicus*.

Length of largest cranidium 12 mm.; most of the cranidia are much smaller. Length of pygidium 5.7 mm, width 14 mm.

The cranidia of this species show considerable variation in the relative width and convexity of the glabella and in the width and convexity of the border. However, no clear-cut forms could be separated and the same boulder yielded individuals of the different types; hence the writer found no reason for separating different species.

P. marginatus differs from *P. typicus* chiefly in the more distinct, convex border, deeper occipital furrow, longer and more curved palpebral lobes, narrower fixed cheeks, and more strongly divergent anterior branch of the facial sutures.

Boulders B-14, B-1 and B-4, Bic (holotype from the first).

Holotype and paratypes: Laval University nos. 335 a-n.

PROTYPUS RETICULATUS Rasetti, n. sp.
Plate 6, figures 14–17

Known from several cranidia.

This species is so similar to the preceding that it is sufficient to indicate the differences.

Compared with *P. marginatus*, it has a somewhat wider and more strongly convex border, separated from the glabella by a deep furrow. But the chief difference is in the beautiful surface ornamentation, represented by a reticulated network of fine, raised lines on the glabella and fixed cheeks.

Length of largest cranidium 11 mm.

Holotype and paratypes (from Bic, boulder unknown): Geol. Surv. Canada nos. 9487, 9487a-b.

REFERENCES

ARKELL, W. J., and J. A. MOY-THOMAS, 1940, Paleontology and the taxonomic problem. In Huxley, The New Systematics, pp. 395–410. Oxford.

BEECHER, C. E., 1897, Outline of a natural classification of the trilobites: Am. Jour. Sci., ser. 4, vol. 3, pp. 89–106, 181–207.

BILLINGS, E., 1865, Paleozoic Fossils, vol. 1. Geol. Surv. Canada.

——, 1872, On some new species of Palaeozoic fossils. Canadian Nat. Geol., vol. 6, pp. 213–222.

CLARK, T. H., 1924, The paleontology of the Beekmantown series at Lévis, Quebec: Bull. Am. Paleontology vol. 10, no. 41, pp. 1–136.

DE BEER, G. R., 1936, Embryology and Evolution. Oxford.

——, 1940, Embryology and Taxonomy. In Huxley, The New Systematics, pp. 365–394. Oxford.

DOBZHANSKI, T., 1944, On species and races of living and fossil man: Am. Jour. Phys. Anthropol., vol. 2, pp. 251–265.

ELLS, R. W., 1883, Report on the geological formations in the Gaspé peninsula: Geol. Surv. Canada, Rept. Prog., 1880–82, pp. DD1–32.

——, 1889, Second report on the geology of a portion of the Province of Quebec: Geol. Surv. Canada, Ann. Repts., vol. 3, pt. 2, pp. 1K–120K.

HOWELL, B. F., 1935, New Middle Cambrian Agnostian trilobites from Vermont: Jour. Paleontology, vol. 9, pp. 218–221.

HOWELL, B. F. 1944, Correlation of the Cambrian formations of North America: Geol. Soc. Am. Bull., vol. 55, pp. 993–1003.

HOWELL, B. F., E. A. Frederickson, C. Lochman, G. O. Raasch and F. Rasetti, 1947, Terminology for describing Cambrian trilobites: Jour. Paleontology, vol. 21, pp. 72–76.

JAEKEL, O., 1909, Ueber die Agnostiden: Zeits. deutsch. geol. Ges., vol. 61, pp. 380–401.

KOBAYASHI, T., 1935, Cambrian faunas of South Chosen, with a special study of the Cambrian trilobite genera and families. Fac. Sci. Imp. Univ. Tokyo Jour., sect. 2, vol. 4, pt. 2, pp. 49–344.

——, 1939, On the Agnostids: Tokyo Imp. Univ. Fac. Sci., Jour., sec. 2, vol. 5, pt. 5, pp. 69–198.

——, 1943, Brief notes on the Eodiscids. I: Their classification with description of a new species and a new variety; II: Phylogeny of the Dawsoniidea: Imp. Acad. Tokyo Proc., vol. 19, pp. 37–42, 43–47.

LOCHMAN, C., 1947, Analysis and revision of eleven Lower Cambrian trilobite genera: Jour. Paleontology, vol. 21, pp. 59–71.

POULSEN, C., 1927, The Cambrian, Ozarkian and Canadian faunas of northwest Greenland: Meddelelser om Grønland, vol. 70, pp. 237–343.

RASETTI, F., 1944, Upper Cambrian trilobites from the Lévis conglomerate: Jour. Paleontology, vol. 18. pp. 229–258.

——, 1945a, New Upper Cambrian trilobites from the Lévis conglomerate: Jour. Paleontology, vol. 19, pp. 462–478.

——, 1945b, Description supplémentaire de trois genres de trilobites cambriens: Natur. Canadien, vol. 72, pp. 117–124.

——, 1945c, Evolution of the facial sutures in the trilobites *Loganopeltoides* and *Loganopeltis:* Am. Jour. Sci., vol. 243, pp. 44–50.

——, 1945d, Faunes cambriennes des conglomérats de la "formation de Sillery": Natur. Canadien, vol. 72, pp. 53–67.

——, 1945e, Fossiliferous horizons in the "Sillery formation" near Lévis, Quebec: Am. Jour. Sci., vol. 243, pp. 305–319.

——, 1946a, Cambrian and early Ordovician stratigraphy of the lower St. Lawrence valley: Geol. Soc. America Bull., vol. 57, pp. 687–706.

——, 1946b, Early Upper Cambrian trilobites from western Gaspé: Jour. Paleontology, vol. 20, pp. 442–462.

RAYMOND, P. E., 1917, Beecher's classification of trilobites, after twenty years: Am. Jour. Sci., ser. 4, vol. 43, pp. 196–210.

RESSER, C. E., 1933, Preliminary generalized Cambrian time scale: Geol. Soc. America Bull., vol. 44, pp. 735–756.

RESSER, C. E., 1938, Cambrian system (restricted) of the southern Appalachians: Geol. Soc. America Special Papers, 15, pp. 1–140.

——, 1942a, Fifth contribution to nomenclature of Cambrian fossils: Smithsonian Misc. Coll. vol. 101, no. 15, pp. 1–58.

——, 1942b, New Upper Cambrian trilobites: Smithsonian Misc. Coll., vol. 103, no. 5, pp. 1–136.

RICHARDSON, J., 1859, Report on a portion of the Gaspé peninsula: Geol. Surv. Canada, Rept. Prog. 1858, pp. 105–169

RICHTER, R., 1932, Crustacea. In Handwörterbuch der Naturwiss., 2nd. ed., Jena, pp. 840–863.

SIMPSON, G. G., 1943, Criteria for genera, species and subspecies in zoology and paleozoology: Ann. New York Acad. Sci., vol. 44, pp. 145–178.

STØRMER, L., 1942, Studies on trilobite morphology. Part II: The larval development, the segmentation and the sutures, and their bearing on trilobite classification: Norsk Geol. Tidskr., vol. 21, pp. 49–164.

STUBBLEFIELD, C. J., 1936, Cephalic sutures and their bearing on current classifications of trilobites: Biol. Rev., vol. 11, pp. 407–440.

SWINNERTON, H. H., 1915, Suggestions for a revised classification of trilobites: Geol. Mag., dec. VI, vol. 2, pp. 487–496, 538–545.

ULRICH, E. O., 1922, Ordovician "hypoparian" genera of trilobites. Geol. Soc. America Bull., vol. 33, p. 205.

WALCOTT, C. D., 1890a, A review of Dr. R. W. Ells' second report on the geology of a portion of the Province of Quebec: Am. Jour. Sci., 3rd ser., vol. 39, pp. 101–115.

——, 1890b, The fauna of the Lower Cambrian or *Olenellus* zone: U. S. Geol. Surv., Tenth Ann. Rept., pp. 510–658.

——, 1912, Cambrian Brachiopoda. U. S. Geol. Surv. Mon. 51, pp. 1–872.

——, 1916, Cambrian geology and paleontology. No. 5: Cambrian trilobites: Smithsonian Misc. Coll., vol. 64, no. 5, pp. 303–456.

WARBURG, ELSA, 1925, The trilobites of the *Leptaena* limestone in Dalarne: Geol. Inst. Univ. Upsala Bull., vol. 17, pp. 1–446.

WHITEHOUSE, F. W., 1936, The Cambrian faunas of north-eastern Australia. Parts 1 and 2: Mem. Queensland Mus., vol. 11, pp. 59–112.

——, 1939, The Cambrian faunas of north-eastern Australia. Part 3: Univ. Queensland Papers, vol. 1, no. 7, pp. 179–282.

MANUSCRIPT RECEIVED MAY 8, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 25–29, PL. 7, JANUARY 1948

CEPHALIC SUTURES IN *LOGANOPELTOIDES* AND THE ORIGIN OF "HYPOPARIAN" TRILOBITES

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ABSTRACT—A new species of *Loganopeltoides*, *L. kindlei*, is described. New evidence confirms the writer's assumption that at least certain "hypoparian" trilobites, e.g. *Loganopeltis depressa*, originated from opisthoparian forms through coalescence of the anterior and posterior branches of the facial suture. A parallel case of evolution in another group of trilobites is mentioned.

INTRODUCTION

Two years ago, the writer (Rasetti, 1945) described the structure of a peculiar trilobite, *Loganopeltoides*, in which the anterior and posterior branches of the facial suture appeared to be fused into one. An early Ordovician form, *Loganopeltis*, extremely similar to *Loganopeltoides* in all other respects, shows the complete disappearance of the dorsal sutures connecting the eyes with the margin of the cephalon, hence would be designated as a "hypoparian" trilobite according to Beecher's classification. The writer suggested that *Loganopeltis* derived from *Loganopeltoides* and that other "hypoparian" forms may have originated in a similar manner.

The purpose of this paper is to present further evidence bearing on this question. Through the courtesy of Dr. Cecil H. Kindle, the writer was able to study and will presently describe a new species of *Loganopeltoides* from western Newfoundland which shows an earlier step in the process of evolution from opisthoparian to "hypoparian" forms. Additional observations made on the previously described species will also be presented. Finally, another case of evolution in the same direction in another group of trilobites occurring in the Dresbachian strata of the upper Mississippi Valley will be mentioned.

The writer is greatly indebted to Dr. Cecil H. Kindle for the loan of his material from Newfoundland; to Dr. L. D. Burling for the loan of specimens in possession of the Geological Survey of Canada; to Dr. G. Arthur Cooper for permission to study the material in the collections of the United States National Museum; and to Dr. Gilbert O. Raasch for information regarding certain trilobites from the upper Mississippi Valley.

SYSTEMATIC DESCRIPTIONS

Genus LOGANOPELTOIDES Rasetti, 1945

LOGANOPELTOIDES ZENKERI (Billings)

Plate 7, figures 1–4

Conocephalites zenkeri BILLINGS, 1860, Canadian Naturalist, vol. 5, p. 305, fig. 4; 1863, Geology of Canada, Geol. Surv. Canada, p. 233, fig. 253; 1865, Geol. Surv. Canada, Palaeozoic Foss., vol. 1, p. 398, fig. 375.

Ptychoparia zenkeri (Billings). MILLER, 1889, North Am. Geol. Paleont., p. 565, fig. 1052.

Loganopeltis zenkeri (Billings). RASETTI, 1943, Jour. Paleontology, vol. 17, p. 104; 1944, Jour. Paleontology, vol. 18, p. 248, pl. 38, figs. 27, 28, 47.

Loganopeltoides zenkeri (Billings). RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 46, pl. 1, figs. 2, 3.

The conclusions reached by the writer in 1945 are confirmed by the study of additional material. There is only a suture (at least distally: see later discussion) extending from the eye to the margin of the cephalon, and it follows the summit of a ridge. This suture appears to represent the anterior and posterior branches of the facial suture fused into one, as it will appear clearly from the study of two other related species in which the fusion is incomplete.

In order to show conclusively that this ridge is a real feature of the animal and not, as it might be thought, the result of an accident of preservation, the specimens studied are listed, with remarks about the appearance of the ridge. It must be understood that the specimens studied occur in crystalline limestone and that they do not show the

slightest crushing or other form of distortion. This is evidenced not only by the specimens of *Loganopeltoides* but also by thousands of individuals of other trilobites collected from the same boulders in the Lévis conglomerates. Although *Loganopeltoides* possessed a thinner shield than any other trilobite known to the writer with the possible exception of the Olenellidae, the cephala of *Loganopeltoides* do not show any fractures, indicating that no deformation of the rock occurred after sedimentation.

A list of the specimens on which this study was based follows.

No. 1—Large cephalon; left side destroyed by weathering, right side perfectly preserved and showing ridge. Geol. Surv. Canada 849, holotype, Figured previously (Rasetti, 1944, pl. 38, fig. 27).

No. 2—Medium-sized cephalon; left side incompletely preserved, right side well preserved and showing ridge. Laval University 1148a, plesiotype. Figured previously (Rasetti, 1944, pl. 38, fig. 28).

No. 3—Small cephalon; only left side preserved showing ridge very clearly. USNM collections (not numbered).

No. 4—Small cephalon; preservation imperfect but ridge visible on right side. USNM collections (not numbered).

No. 5—Small cephalon; preservation of surface rather poor, but ridge visible on both sides. USNM collections (not numbered).

No. 6—Small cephalon; only right side preserved, showing ridge clearly. Geol. Survey Canada 7685a. Figured (pl. 7, fig. 4).

No. 7—Small cephalon, same characteristics as the preceding. Geol. Surv. Canada 7685b. Figured (pl. 7, fig. 3).

No. 8—Perfect impression of small cephalon, showing ridge on both sides. Geol. Surv. Canada 7685, plesiotype. Figured previously (Rasetti, 1945, pl. 1, fig. 2).

No. 9—Small cephalon; right side alone preserved; eye and proximal portion of ridge broken off in extracting specimen from matrix, but ridge very clearly visible near margin. Geol. Surv. Canada 7685c. Figured (pl. 7, fig. 1).

No. 10—Small cephalon; left side not preserved but right side showing ridge and even suture along ridge very clearly. Laval University no. 1148c. Figured (pl. 7, fig. 2).

In conclusion, all the specimens of *Loganopeltoides zenkeri* observed by the writer show the ridge in the identical position whenever the corresponding area of the cephalon is preserved. It is obviously impossible that such a constant and regular feature could have arisen through an accident of preservation.

It is perhaps not superfluous to remark that in this species, as well as in *Loganopeltis depressa*, there is often an irregular ridge running backward and outward from the eye. Sometimes this ridge appears clearly on one side only, in other cases it appears on both sides but is not symmetrical. In the writer's opinion, this ridge has no connection whatever with the facial sutures. It is merely a stronger representative of the numerous anastomosing ridges so often observed on the brim and free cheeks of Cambrian Ptychoparid trilobites. The writer's published illustrations of *Loganopeltis depressa* show this quite clearly. The free cheeks of opisthoparian trilobites sometimes also show a stronger ridge of this type; it may be seen, for example, in the writer's published illustrations of *Diplapatokephalus levisensis* (Rasetti, 1943, pl. 19, fig. 7).

All the specimens discussed were collected from late Upper Cambrian boulders (*Hungaia magnifica* zone) in the conglomerates of the Lévis formation at Lévis, Quebec.

LOGANOPELTOIDES MINUTUS (Rasetti)
Plate 7, figure 5

Loganopeltis minuta RASETTI, 1944, Jour. Paleontology, vol. 18, p. 248, pl. 38, fig. 26.
Loganopeltoides minutus (Rasetti). RASETTI, 1945, Am. Jour. Sci., vol. 243, p. 47, pl. 1, fig. 1.

No new material of this species has become available, but after studying the new species of *Loganopeltoides* described in this paper, the writer is satisfied that the anterior and posterior branches of the facial suture are not fused together, but run parallel and within a very short distance of each other. The left side of the previously figured head is illustrated again under higher enlargement. The eye and surrounding portions of the shield have been lost in extracting the specimen from the matrix, but the distal portions of the sutures are very well preserved. One can see the sutures running close to each other, then diverging a short distance before reaching the margin, thus rounding off the corners of the brim and of the posterior limbs.

Locality: same as for the preceding species.

LOGANOPELTOIDES KINDLEI Rasetti, n. sp.
Plate 7, figures 6–9

Known from two cranidia.

Cranidium semicircular, posterior margin straight. Glabella strongly convex, elevated above the fixed cheeks, slightly tapered, rounded in front. Posterior glabellar furrows rather deep, starting from the dorsal furrow, very oblique. Two other pairs very short, pit-like, very close to the dorsal furrow. Occipital furrow well impressed; occipital ring apparently simple. Fixed cheeks and brim convex; brim rather depressed mesially. Border upturned, concave, poorly defined from the brim. Ocular ridges fairly prominent, directed transversely. Palpebral lobes at the level of the anterior fourth of the glabella, their length probably about one-fourth of the glabellar length. Marginal furrow on posterior limbs well impressed, straight.

Anterior and posterior branches of the facial suture both directed outward and forward from the respective ends of the palpebral lobe. The two branches of the suture first approach each other, but do not come together; then diverge again, the anterior branch curving forward, the posterior branch backward. The remaining portion of both branches was apparently marginal; the free cheeks must have consisted of the narrow strips running from the eye to the margin, besides the doublure.

Surface of cranidium with scattered tubercles, besides more numerous smaller granules. The larger tubercles are arranged more or less symmetrically. There are three or possibly four pairs on the glabella, one pair on the brim somewhat forward and inward from the eye, another pair on the fixed cheeks backward and inward from the eye, plus a few less conspicuous pairs on the posterior limbs.

Length of largest cranidium 4.0 mm, width 7.7 mm.

This species differs from *L. minutus* Rasetti, which it most resembles, chiefly in that both branches of the facial suture describe a wider curve before reaching the margin; hence the presence of the sutures appears much more clearly in the present species. Other differences are the proportionately much narrower glabella; the more oblique course of the posterior glabellar furrows; the more anterior position of the eyes; and the different surface ornamentation.

In a limestone boulder from a conglomerate (Kindle, 1943) at the entrance to St. Paul's Inlet, on the west coast of Newfoundland, associated with other late Upper Cambrian trilobites; collected by C. H. Kindle, for whom the species is named.

The holotype and paratype, only specimens known, are property of the Geological Survey of Newfoundland, but are temporarily deposited in the Department of Geology of Rutgers University.

DISCUSSION

The conclusions reached by the writer in his earlier work are essentially confirmed by the present study, with one modification that will be presently discussed.

The new species, *Loganopeltoides kindlei*, shows more clearly than either of the two species of *Loganopeltoides* previously described the presence of facial sutures. The two known specimens are cranidia, lacking the free cheeks. The only unusual character of this species as compared with ordinary opisthoparian trilobites is that the posterior branch of the facial suture is directed forward rather than backward, hence comes within a very short distance of the anterior branch. This species represents precisely the type of trilobite from which the writer, in his earlier work, assumed *Loganopeltoides zenkeri* to be derived. It was suggested that *Loganopeltoides minutus* had this type of sutures, but from the one perfectly preserved specimen available the writer did not feel prepared to state this with certainty. Now, after the discovery of *Loganopeltoides kindlei*, it appears almost certain that both species possess an anterior and a posterior branch of the facial suture.

We may thus imagine the evolution in this line of trilobites to have proceeded as follows. First the anterior and posterior branches of the facial suture approach each other. In the next step the two branches have coalesced into one (*Loganopeltoides zenkeri*), the resulting suture following a ridge. The latter is an unusual feature for the sutures of trilobites, but it is also exceptional for a suture to represent two branches fused together. Finally, the sutures from the

eye to the margin of the cephalon entirely disappear, and we have a "hypoparian" trilobite (*Loganopeltis depressa*).

There is one detail in which the writer believes that his former interpretation must be modified. In the earlier paper, forms with sutures of the type attributed to *Loganopeltoides minutus* were considered proparian. Now it seems more likely, by analogy with another case where the free cheeks are known, that forms like *Loganopeltoides kindlei* and *L. minutus* are opisthoparian. The free cheeks of these trilobites have never been discovered, and it is known that it is sometimes very difficult to distinguish between proparian and opisthoparian trilobites when the cranidia alone are available. For example, *Cedaria* might be assumed to be a proparian genus if one had never seen the free cheeks with their long genal spines. The structure of the cranidia of *Loganopeltoides kindlei* and *L. minutus* is perfectly compatible with the assumption that these trilobites are opisthoparian. One has only to assume that the posterior branch of the facial suture, after reaching the margin of the cephalon, runs marginally or submarginally to the genal angle, then crosses the base of the genal spine, the latter belonging to the free cheek. This is the course of the suture near the genal angle as observed in *Cedaria* and, among "hypoparian" trilobites, for example in *Trinucleus*.

Support for the proposed mode of evolution of "hypoparian" from opisthoparian trilobites is derived from the discovery of an analogous case, made by Dr. Gilbert O. Raasch, who kindly communicated his observations to the writer. Detailed information on the species involved will be published by Dr. Raasch in a forthcoming revision of the Dresbachian trilobites of the upper Mississippi Valley. Here only the essential relevant facts will be mentioned. A long-known trilobite from the Dresbach sandstone of Wisconsin, described by Whitfield as *Agraulos* (*Bathyurus*) *woosteri*, was found by Dr. Raasch (upon examination of better-preserved specimens than those formerly available) to possess sutures of a very unusual type, paralleled only in *Loganopeltoides zenkeri*. The anterior and posterior branches of the facial suture start separately from the respective ends of the palpebral lobe, but after a short distance coalesce into one. Near the margin they again separate, each branch closely following the margin of the cephalon. The posterior branch crosses the base of the genal spine, leaving the latter on the free cheek. Hence each free cheek is reduced to two disconnected parts: a small, subtriangular piece near the eye, and the marginal portion including the doublure and the genal spine. The latter portion usually separated with the decomposition of the soft parts and is not found attached to the cranidium. We have only to assume that later the small "ocular" portions of the free cheeks became fused with the cranidium to explain the evolution of a "hypoparian" form. Thus the marginal suture did not arise independently as it has been assumed by many authors, but remained as a portion of the original facial suture.

EXPLANATION OF PLATE 7

FIGS. *1–4*—*Loganopeltoides zenkeri* (Billings). *1*, Right side of a small cephalon, ×10. The eye and neighboring portions of the test have been broken off, but the ridge is clearly visible near the margin. It also shows the small notch in the marginal outline where the coalescent sutures reach the edge of the cranidium. Geol. Surv. Canada 7685c, plesiotype. *2*, Right side of another small cephalon, ×10. The distal portion of the ridge is very well preserved. Laval U. 1148c, plesiotype. *3*, Small cranidium, ×4; this individual is not quite typical of the species in that the border is slightly convex, as in *L. minutus*. Geol. Surv. Canada 7685b, plesiotype. *4*, Small cranidium, ×4; Geol. Surv. Canada 7685a, plesiotype. Upper Cambrian boulders in the Lévis conglomerate, Lévis, Quebec. (p. 25)

5—*Loganopeltoides minutus* (Rasetti). Left side of cranidium, ×12; Laval U. 1180, plesiotype. Upper Cambrian boulders in the Lévis conglomerate, Lévis, Quebec. (p. 26)

6–9—*Loganopeltoides kindlei* Rasetti, n. sp. *6*, *7*, Cranidium, ×6 and 12; paratype. *8*, Larger cranidium, ×6; holotype. *9*, Right side of same cranidium, ×12. Geol. Survey Newfoundland. Upper Cambrian boulders in a conglomerate, St. Paul's Inlet, western Newfoundland. (p. 27)

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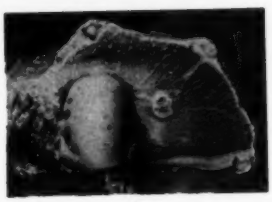

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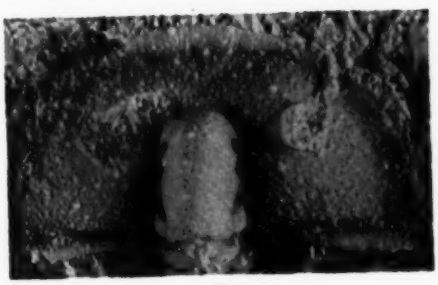

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Rasetti, Cephalic Sutures of *Loganopeltoides*

The writer inclines to believe by analogy that *Loganopeltoides* possessed marginal free cheeks with genal spines (besides the narrow strips running from the eyes to the margin in forms like *L. kindlei* where the two branches had not coalesced), hence derived from an opisthoparian (rather than a proparian) ancestor like *Agraulos woosteri*, which undoubtedly is a close relative of *Cedaria*. It is possible that *Loganopeltoides zenkeri* also possessed small, triangular "ocular" portions of the free cheeks, but this part of the shield is seldom preserved, because the eyes are generally broken off in extracting the specimens from the matrix. Hence further material will be required to settle the last-mentioned point.

MANUSCRIPT RECEIVED JULY 3, 1947.

REFERENCES

KINDLE, C. H., 1943, A preliminary list of late Cambrian trilobites found on the west coast of Newfoundland: Canadian Field-Nat., vol. 57, pp. 7–8.

RASETTI, F., 1943, New Ordovician trilobites from Lévis, Quebec: Jour. Paleontology, vol. 17, pp. 101–104.

——, 1944, Upper Cambrian trilobites from the Lévis conglomerate. Jour. Paleontology, vol. 18, pp. 229–258.

——, 1945, Evolution of the facial sutures in the trilobites *Loganopeltoides* and *Loganopeltis:* Am. Jour. Sci., vol. 243, pp. 44–50.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 30–34, PL. 8, JANUARY 1948

TWO UPPER CAMBRIAN *ELVINIA* ZONE TRILOBITE GENERA

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ABSTRACT—This paper describes two Upper Cambrian trilobite genera from the *Elvinia* zone of the Mid-continent province in North America. Species of a new genus, *Sulcocephalus*, were identified as *Talbotina* by Resser (1942). The genoholotype of *Deadwoodia* is photographed for the first time, and its species are discussed. *Dunderbergia? declivita* Miller (1936) is placed in synonymy.

INTRODUCTION

A STUDY of the *Elvinia* zone fauna of the Upper Cambrian Wilberns limestone in the Central Mineral Region of Texas demonstrated that most of the genera lacked adequate description or needed revision. Later field work and study of the same fauna in the Snowy Range formation of northern Wyoming and southern Montana added to knowledge of this problem. The writer had opportunity to examine the National Museum collections at Washington, D. C. in 1944 and 1945.

Sulcocephalus is a Texas genus of the *Elvinia* (Ironton) fauna interesting because of its unusually restricted vertical range. Its type was mis-identified. *Deadwoodia* is a persistent member of the *Elvinia* zone and has a wide geographic range. The genera are here discussed, redescribed, and refigured. The writer wishes to express the greatest appreciation to Dr. W. Charles Bell for his help in establishing a systematic method of work, to Dr. G. A. Cooper of the National Museum for his aid with photography, and to Dr. Christina Lochman for criticism of this paper.

The notations regarding locality are as follows: "42" refers to the year the collection was made, "12w" to the geographical location, and ".2" to the vertical horizon, e.g. "42-12w.2." Types marked such as CW-32 refer to the writer's personal collection now at Yale University. The term "width" is used to mean distance across the cranidium measured between palpebral lobes or posterolateral limbs. "Length" refers to the longitudinal distance along the center line from the occipital ring to the rim.

SYSTEMATIC PALEONTOLOGY

Genus SULCOCEPHALUS Wilson, n. gen.

Cranidium of average size (in 10 specimens from three localities width ranged from 12.5 to 18 mm. and length from 9 to 13 mm.); length about two-thirds of width. Glabella very prominent, somewhat tapered, convex, evenly curved in longitudinal profile; circumglabellar furrow wide and deep; three pairs of glabellar furrows well incised, becoming progressively longer and deeper posteriorly; occipital furrow deeper at sides than at center; occipital ring quite distinct, arched forward laterally. Rim convex, well defined by a distinct marginal furrow, greatly expanded at center along its anterior, and somewhat so along its posterior margin; brim immediately anterior to glabella slightly arched and from half to equal the thickness of centrally expanded rim, broadened and greatly depressed toward anterior corners of cranidium. Fixed cheeks somewhat less than one-half as wide as glabella, convex in both frontal and longitudinal profile; short and slightly depressed palpebral lobes are situated just posterior to midline of glabella; ocular ridges faint and oblique; posterolateral limbs very broad, straight, greatly depressed, widely and deeply furrowed.

Facial suture intramarginal to center, proceeds slightly inward, curving gently from anterolateral corners of cranidium to palpebral lobe, around which it curves and proceeds outward, making a 60° angle from the longitudinal axis.

Free cheek and pygidium unknown.

Surface either smooth or minutely granulose.

The central expansion of the posterior

side of the rim, the convex fixed cheeks, deeply incised furrows, and prominent glabella are distinguishing characteristics of *Sulcocephalus*. The genus differs from *Talbotina*, in which its type species was placed by Resser (1942), in being larger, having much deeper furrows, wider posterolateral limbs, and a more medially enlarged rim. *Talbotina* is a member of the *Cedaria* zone, whereas *Sulcocephalus* is found with *Irvingella* and *Ptychopleurites* in the *Irvingella* subzone at the very top of the *Elvinia* zone and sometimes in the *Eoorthis-Billingsella* brachiopod bed immediately above the Ironton fauna.

Two valid species of *Sulcocephalus* are known from three localities in Texas.

Genotype: *Talbotina candida* Resser.

SULCOCEPHALUS CANDIDUS (Resser)
Plate 8, figures 1, 2

Talbotina candida RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 107, pl. 21, figs. 27, 28.

Talbotina ulrichi RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 107, pl. 21, fig. 26.

Original description.—The glabella covers somewhat less than half the cranidial area and is sculptured by three sets of recurved furrows and a deep, wide occipital furrow. The fixigenes average about half the glabellar width. Posterolateral limbs are fairly long and of normal width. The brim, about equal in width to the fixigenes, is separated into rim and preglabellar area. The somewhat swollen rim widens to the center, chiefly by rather sudden expansion rearward. The eyes of average size, are situated behind the midpoint of the glabella. Eye lines present. Convexity is about average in amount, while the relief is pronounced. The surface is abundantly granulose. Libragene, thorax, and pygidium unknown.

Remarks.—The genoholotype is a beautifully preserved cranidium. Nothing need be added to the original specific description. Resser's "*Talbotina ulrichi*" appears to the writer to represent an imperfect cranidium of *Sulcocephalus candidus*. Such important features as width of fixed cheeks, form and breadth of preglabellar area, relative size and prominence of the glabella and course of facial sutures are the same on Resser's two holotypes.

Occurrence.—*Sulcocephalus candidus* (Resser) is an uncommon member of the *Irvingella* subzone one to three feet below the top of the *Elvinia* zone, basal Wilberns limestone. It has been collected from the Central Mineral Region of Texas on Cold Creek, opposite the north end of Sponge Mountain, San Saba County (U. S. National Museum loc. 14b); 4 miles north of Marble Falls on the Burnet Highway, Burnet County (42-8w.5); and from the Threadgill Creek section, southeastern Mason County (42–12w-.14).

Holotype.—Cranidium, U. S. Nat. Mus. No. 108841, loc. 14b, Cold Creek, San Saba County, Texas.

Hypotypes.—Cranidium, U. S. Nat. Mus. No. 108840 (labeled *Talbotina ulrichi*), loc. 14b, Cold Creek.

Cranidium, CW-33 Sta. 42-12w.14, Threadgill Creek.

Cranidium, CW-34 Sta. 42-12w.14, Threadgill Creek.

SULCOCEPHALUS BENESULCATUS Wilson, n. sp.
Plate 8, figures 3–5

Cranidium small (9 mm. long by 13 mm. wide), moderately convex. Glabella prominent, well tapered, convex, flat in longitudinal profile, only slightly depressed at its anterior end; circumglabellar furrow extremely wide and deep; three pairs of glabellar furrows present. Rim convex, well defined, greatly thickened centrally along anterior and posterior margins giving it a triangular shape; fixed cheeks less than one-half width of glabella, convex; posterolateral limbs trend almost 90° to longitudinal axis.

Facial suture intramarginal to center, proceeds straight back from anterior corners of cranidium to palpebral lobe, around which it curves, and then continues its outward course at a 60° angle from the longitudinal axis.

Free cheek and pygidium unknown.

Ornamentation unknown.

Remarks.—This species is based upon a single specimen with most of its outer surface missing. It differs from *S. candidus* (Resser) in having a thicker, more triangular rim, less flared and expanded anterior corners of the cranidium, and a much more tapered glabella. The specimen upon which this species is based is much smaller than the holotype of *Sulcocephalus candidus*, but the writer does not believe ontogeny could account for these differences.

Occurrence.—Associated with small specimens of *S. candidus* (Resser) in the *Irvingella* subzone, 3 feet below the top of the *Elvinia* zone of the lower Wilberns limestone, on Threadgill Creek, southeastern Mason County, Texas (42-12w.14).

Holotype.—Cranidium, CW-32 Sta. 42-12w.14, Threadgill Creek.

Genus DEADWOODIA Resser, 1938

Original description.—This trilobite genus is represented by a single cranidium. However, it appears among undescribed material of Ironton age, from several localities and consequently description is warranted. The cranidium is characterized by a very large, nearly quadrate glabella, highly arched in both directions and standing high above the fixigenes. Glabellar furrows essentially absent. Occipital furrows deep but narrow. Brim is wide, concave as a whole. Preglabellar area slightly convex, dipping steeply down from the dorsal furrow. Anterior furrow shallow, with the essentially flat rim turned nearly into a horizontal position. Fixigenes narrow, as well as the posterolateral limbs. Eyes rather large, strongly bowed, and palpebral lobes separated by deep furrows.

Supplementary description.—Cranidium slightly wider across posterolateral limbs than long (14 mm. by 11 mm. on largest specimen), almost box-shaped in profile because of the steeply inclined anterior portion of the cranidium and the lack of glabellar curvature. Glabella long, occupying over two-thirds length of cranidium, tumid, standing very high above fixed cheeks, tapered only slightly anteriorly and in young individuals completely parallel-sided; three pairs of faint glabellar furrows present, first pair almost invisible and directed transversely, whereas the trend of the other two is noticeably posterior; occipital furrow moderately incised; occipital ring flat, barely tapered at lateral edges. Brim distinct, bulging slightly in the preglabellar area, often swollen to form a platform that merges with flat fixed cheeks, and steeply depressed from this platform to the moderately incised frontal furrow; rim fairly thick (varies specifically from one-half to one-third thickness of brim), widely arcuate in shape; fixed cheeks less than one-third width of glabella and completely flat; palpebral lobes rather large, in same plane as fixed cheeks; posterolateral limbs narrow, moderately furrowed, directed only slightly backward.

Facial suture intramarginal to center of rim, trends but slightly inward to edge of ocular ridge, around long palpebral lobe and outward, making an 80° angle with longitudinal axis.

Free cheek and pygidium unknown.

All specimens of any size bear small granules on the glabella and apparently are smooth on other portions of the cranidium.

Remarks.—The genotype, *Deadwoodia panope* (Walcott), occurs in the Black Hills. A more common species, *Deadwoodia duris* (Walcott), occurs in northern Wyoming,

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EXPLANATION OF PLATE 8

FIGS. *1, 2*—*Sulcocephalus candidus* (Resser). *1*, Hypotype, dorsal view of clay squeeze of cranidium, ×2, CW-34, Sta. 42-12w.14, Threadgill Creek, Mason Co., Texas; *2*, hypotype, dorsal view of imperfect cranidium, ×2, CW-33, Sta. 42-12w.14, Threadgill Creek, Mason Co., Texas (p. 31)

3–5—*Sulcocephalus benesulcatus* Wilson, n. sp. Holotype, dorsal, profile, and frontal views of imperfect cranidium with outer surface missing, ×2, CW-32, Sta. 42-12w.14, Threadgill Creek, Mason Co., Texas (p. 31)

6–8—*Deadwoodia panope* (Walcott). Genoholotype, dorsal profile, frontal views of incomplete cranidium, ×2, U. S. Nat. Mus. No. 23856, Spring Creek Canyon, Black Hills, South Dakota (p. 33)

9–17—*Deadwoodia duris* (Walcott). *9–11*, Holotype, dorsal, profile, and frontal views of small cranidium, ×2, U. S. Nat. Mus. No. 62818, loc. 107E, Ore Hill Quarry, Bedford Co., Pennsylvania; *12*, hypotype, dorsal view of small cranidium with well developed preglabellar platform, ×2, CW-41, Sta. 42-9w.9, Baldy Mountain, Burnet Co., Texas; *13–15*, hypotype, profile, frontal, and dorsal views of large and fairly complete cranidium showing well developed preglabellar platform, ×2, CW-43, Sta. 42-12w.2, Threadgill Creek, Mason Co., Texas; *16, 17*, hypotype, profile and dorsal views of cranidium possessing a slight swelling of posterior margin of central portion of rim, ×2, CW-63, Sta. 44-4w.2, Shoshone Canyon, Wyoming (p. 33)

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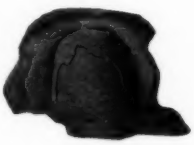

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Wilson, Upper Cambrian Trilobite Genera

Texas, Wisconsin, and Pennsylvania. The genus is restricted to the *Elvinia* zone.

Genotype.—*Deadwoodia panope* (Walcott).

DEADWOODIA PANOPE (Walcott)
Plate 8, figures 6–8

Ptychoparia (*Liostracus*) *panope* WALCOTT, 1890, U. S. Nat. Mus. Proc., vol. 13, p. 275, pl. 21, fig. 13 (sketch).

Deadwoodia panope (Walcott) RESSER, 1938, Smithsonian Misc. Coll., vol. 97, no. 10, p. 29.

Original description.—Of the species we have only the portions within the facial sutures. Glabella convex, sides converging a very little towards the broadly rounded front; occipital furrow well defined and arched forward at the center; occipital segment a little broader at the center than at the sides, slightly convex and arched forward near the center; dorsal groove distinct all about the glabella.

Fixed cheeks of medium width; palpebral lobes rather long, narrow and separated from the cheeks by a narrow and distinctly marked groove; a narrow ocular ridge crosses the cheeks from the palpebral lobe to the dorsal furrow.

Frontal limb of medium length and bent downward from the dorsal suture to where it curves outward and merges into the flattened border. Surface smooth.

Occurrence.—Resser gives the locality for the genoholotype as: "Upper Cambrian, Deadwood (Ironton equivalent); Spring Creek Canyon, about 7 miles southwest of Rapid City, Black Hills, South Dakota." This spot is in the center of the N½ section 12, T. 1 S., R. 6 E., approximately where Deadman Creek joins Spring Creek and north of the Stratosphere Bowl parking place. The species is represented by poor specimens from the Wilberns limestone of Texas and the Ore Hill member of the Gatesburg formation in Pennsylvania.

Genoholotype.—Cranidium, U. S. Nat. Mus. No. 23856, Spring Creek Canyon, South Dakota.

DEADWOODIA DURIS (Walcott)
Plate 8, figures 9–17

Asaphicus ? duris WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 392, pl. 63, figs. 8, 8a.

Dunderbergia ? declivita MILLER, 1936, Jour. Paleontology, vol. 10, no. 1, p. 30, pl. 8, figs. 37, 38.

Original description.—The cranidium representing this species is not unlike that of *A. ? florus* . . . but is proportionately broader, and its outer surface is closely granulated.

Supplementary description.—Cranidium moderate in size, ranging up to 14 mm. wide by 11 mm. long; total convexity great, in longitudinal profile posterior portion horizontal whereas anteriorly a broad, even curve is described. Glabella quite large and slightly tapered anteriorly in adult specimens, broadly rounded at front, convexity great in both directions; three pairs of faint glabellar furrows present; occipital furrow moderately deep, occipital ring broad and untapered. Brim possesses a distinct platform immediately anterior to circumglabellar furrow which merges laterally with the flat fixed cheeks, anterior portion of brim steeply depressed to well incised marginal furrow; rim fairly thick, a little more than one-third breadth of brim, describes a broad curve, thickens quite noticeably to center; fixed cheeks quite flat, rather narrow but sharply expanded laterally at median line of cranidium; palpebral lobes large, well curved, not depressed; posterolateral limbs well furrowed, rather narrow, and almost straight.

Ornamentation consists of minute granules on glabella.

Remarks.—Miller (1936) described a new species, *Dunderbergia ? declivita*, the holotype of which is actually a large cranidium of *Deadwoodia duris* (Walcott). His complete description and photographs add greatly to knowledge of this species. He identified his holotype as *Dunderbergia* with some reservation, pointing out that: "It differs from *D. nitida* in that the border is more steeply inclined from the glabella to the rim, not convex as in *D. nitida*, and in the flat, platform-like form of the cheeks bordering the sides of the glabella."

In addition to the differences pointed out by Miller, the flared anterior portion of the cranidium, wide brim, and small palpebral lobes of the genotype *Dunderbergia nitida* distinguish it from all species of *Deadwoodia*.

The two species of *Deadwoodia* are very similar, their only difference being that *D. duris* possesses a very definite preglabellar platform whereas the genotype, *D. panope*, shows only a faint trace of this bulge. Miller mentions undescribed "varieties or closely related species" of "*Dunderbergia ? declivita*" in the *Elvinia* zone beds in Teton and Gros Ventre Mountains. The Shoshone Canyon section (44-4w) yielded what may be con-

sidered a variety of *Deadwoodia duris*. The specimen possesses a slight central swelling along the posterior margin of the rim (Pl. 8, figs. 15, 16).

Occurrence.—Miller gives the location of *Dunderbergia ? declivita* as "Gallatin formation, limestones 175 feet below the top; northwest ¼, T. 39 N., R. 92 W., Dry Creek, Fremont County, Wyoming." These beds in the Bridger Range are now known as the Snowy Range member of the Boysen formation.

In northern Wyoming the writer collected numerous specimens from crevices in the *Collenia major* algae reef (Columnar limestone) near the base of the Snowy Range formation near the mouth and along the south side of Shoshone Canyon, 7 miles west of Cody, Wyoming. At most localities in Texas the species is present in the middle portion of the *Elvinia* zone; it was found at one locality in the lower part of the *Elvinia* zone, where it was associated with *Iddingsia alpersensis* Resser and *Berkeia wichitaensis* Resser. Vertically it ranges from 26 to 55 feet above the base of the Wilberns limestone. Stations 42-9w.9, 9w.10 Baldy Mountain; 42-10w.7 Smoothingiron Mountain; 42-12w-.2, 12w.10 Threadgill Creek in the Central Mineral Region of Texas. The species is represented in the Ore Hill limestone of the Gatesburg formation at an old lime quarry two miles north of Baker's Summit, ¼ mile east of the junction of the Roaring Springs road with the Ore Hill road, Bedford County, Pennsylvania (U. S. Nat. Mus. loc. 107E). Numerous poorly preserved cranidia are present in the Ira Edwards Collection of the Milwaukee Public Museum (on loan at the National Museum, Washington, D. C.). These specimens are from the Upper Ironton Greensand in the Kendall Quadrangle area, Wisconsin (Milwaukee Pub. Mus. loc. 103, and loc. 78).

Holotype.—Cranidium, U. S. Nat. Mus. No. 62818 (labeled *Modocia duris*), loc. 107E, Bedford County, Pennsylvania.

Hypotypes.—Cranidium, CW-43 Sta. 42-12w.2, Mason County, Texas.

Cranidium, CW-41 Sta. 42-9w.9, Burnet County, Texas.

Cranidium, CW-63 Sta. 44-4w.2, Shoshone Canyon, Wyoming.

MANUSCRIPT RECEIVED JANUARY 20, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 35–39, PL. 9, 1 TEXT-FIG., JANUARY 1948

LOWER ORDOVICIAN BRACHIOPODS FROM JUNEE DISTRICT, TASMANIA

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ABSTRACT—A small collection of brachiopods from Junee District, Tasmania, made recently by S. Warren Carey and Eric Karmberg, is described. This is of interest in being the first record of the typical Lower Ordovician (Canadian) brachiopod genera *Tritoechia* and *Syntrophopsis* from the Southern Hemisphere. Three new species are described.

INTRODUCTION AND ACKNOWLEDGMENTS

A SMALL collection of brachiopods from the Junee District, Tasmania, was made by Dr. S. Warren Carey, former Government Geologist of Tasmania and Eric Karmberg, Surveyor for Australian Newsprint, Ltd., and was sent to me for identification. I am indebted to Dr. Carey for the opportunity to examine these specimens and for the use of his field notes, and to Dr. R. S. Bassler for facilities for working at the U. S. National Museum, Washington, D. C.; I am specially grateful to Dr. G. A. Cooper of the same institution for the use of comparative material in the brachiopod collections in his charge, for discussion of the problems that have risen in this study and for the photographs that are reproduced in Plate 9.

The first record of fossils from this locality is that of R. Etheridge, Jr., who described some poorly preserved specimens from the Florentine Valley of Tasmania (1904); these included trilobite fragments and a brachiopod, which he suggested was related to *Orthis lenticularis* Wahlenberg.

In the years 1937 and 1938 the late Dr. A. N. Lewis carried out gelogical field work in the Tyenna Valley, west of Hobart, and gave (1940) the most detailed account yet published of the geology of the district. He sent fossils from Junee to Prof. T. Kobayashi, who described them (1940) as four new species of trilobites, one new gastropod species and a brachiopod, which he referred to *Orusia* (?) sp., stating that the latter was similar to the form described by Etheridge (1904) from the Florentine Valley.

The present collection of specimens comes from Junee and from Wherret's Lookout, Currowang Gully. Wherret's Lookout is 20 miles south of Strezlecki's (1845) Mt. Humboldt (the same as Mount Field West of recent maps); Junee is a small township on the Tyenna River, a tributary of the Derwent River, 65 miles west of Hobart and ten

FIG. 1. Locality Map of Tasmania

miles southeast of Wherret's Lookout. This locality is on the main divide, near the headwaters of the Florentine River (a tribuatry of the Derwent River) and the Huon River, both of which flow to the east coast, and the Gordon River, which flows to the west coast of Tasmania. (See accompanying map, figure 1.)

According to Dr. S. W. Carey the brachio-

pods described in this paper come from the same outrop of Junee limestone and mudstone as the trilobites described by Kobayashi. From the adjacent Adamsfield Valley Dr. C. Teichert (1947, p. 420) has recognized a Piloceroid fauna which Dr. Carey believes to occur stratigraphically below the Junee limestone.

The material described in the present paper consists chiefly of internal and external molds in leached, sandy mudstones, and from these impressions rubber casts have been made and photographed.

DESCRIPTION OF SPECIES

Suborder CLITAMBONOIDEA Öpik, 1934

ÖPIK, A., 1934, Uber Klitamboniten. Universit. Tartuensis (Dorpatensis) Acta et Comment., Axxvi5.

EXPLANATION OF PLATE 9

All specimens are in the collection of the Geological Survey of Tasmania. The photographs were taken by Dr. G. A. Cooper, and are not retouched.

FIGS. *1a–1i*—*Tritoechia lewisi* Brown, n. sp. (p. 37)

1a—Rock slab showing internal molds of ventral and dorsal valves, including holotype, ×1. (T. G. S. 74X1).

1b—Rubber mold of ventral valve (*1c*) showing high interarea, convex deltidium and foramen. (Mold of T. G. S. 74X1, k.)

1c—Natural internal mold of portion of ventral valve, excavated to show high flat interarea, high convex deltidium and foramen, ×3. (T. G. S. 74X1, k.)

1d—Holotype. Natural internal mold of ventral valve showing impressions of muscle scars and dental plates, and the infilling of the pedicle foramen, ×3. (T. G. S. 74X1, a.)

1e—Rubber mold of holotype (*1d*) showing dental plates and muscle field, ×3. (Mold of T. G. S. 74X1, a.)

1f—Natural internal mold of dorsal valve on reverse side of specimen, ×3. (T. G. S. 74X1, z.)

1g—Rubber mold of interior of dorsal valve, with interarea, simple cardinal process, socket-plates and one chilidal plate visible. ×3. (Mold of T. G. S. 74X1, z.)

1h—Rubber mold of portion of ventral valve showing external ornamentation, ×4. (Mold of T. G. S. 74X1, y.)

1i—Rubber mold of interior of dorsal valve showing cardinalia and median septum, ×4. (Mold of T. G. S. 74X1, e.)

Locality. Wherret's Lookout, Currawong Gully, Junee District, Tasmania.

FIGS. *2a–2f*—(?) *Tritoechia careyi* Brown, n. sp. (p. 37)

2a—Natural cast of ventral valve showing external ornamentation, ×2. (T. G. S. 81C6, a.)

2b—Rubber mold of impression of dorsal valve showing external ornamentation and slight sulcus, ×2. (Mold of T. G. S. 81C10.)

2c—Rubber mold of impression of dorsal valve showing external ornamentation, ×2. (Mold of T. G. S. 81C6, b.)

2d—Natural internal cast of dorsal valve showing cardinal characters and distortion, ×3. (T. G. S. 81C7, c.)

2e—Holotype. Natural internal mold of ventral valve showing impressions of dental plates, adductor and diductor muscle scars and anterior median septum, ×3. (T. G. S. 81C7, a.)

2f—Rubber mold of holotype (*2e*) to show ventral interior, ×4. (Mold of T. G. S. 81C7, a.)

Locality. Trilobite Bed, Junee on Tyenna River, Tasmania.

FIGS. *3a–3d*—*Syntrophopsis karmbergi* Brown, n. sp. (p. 38)

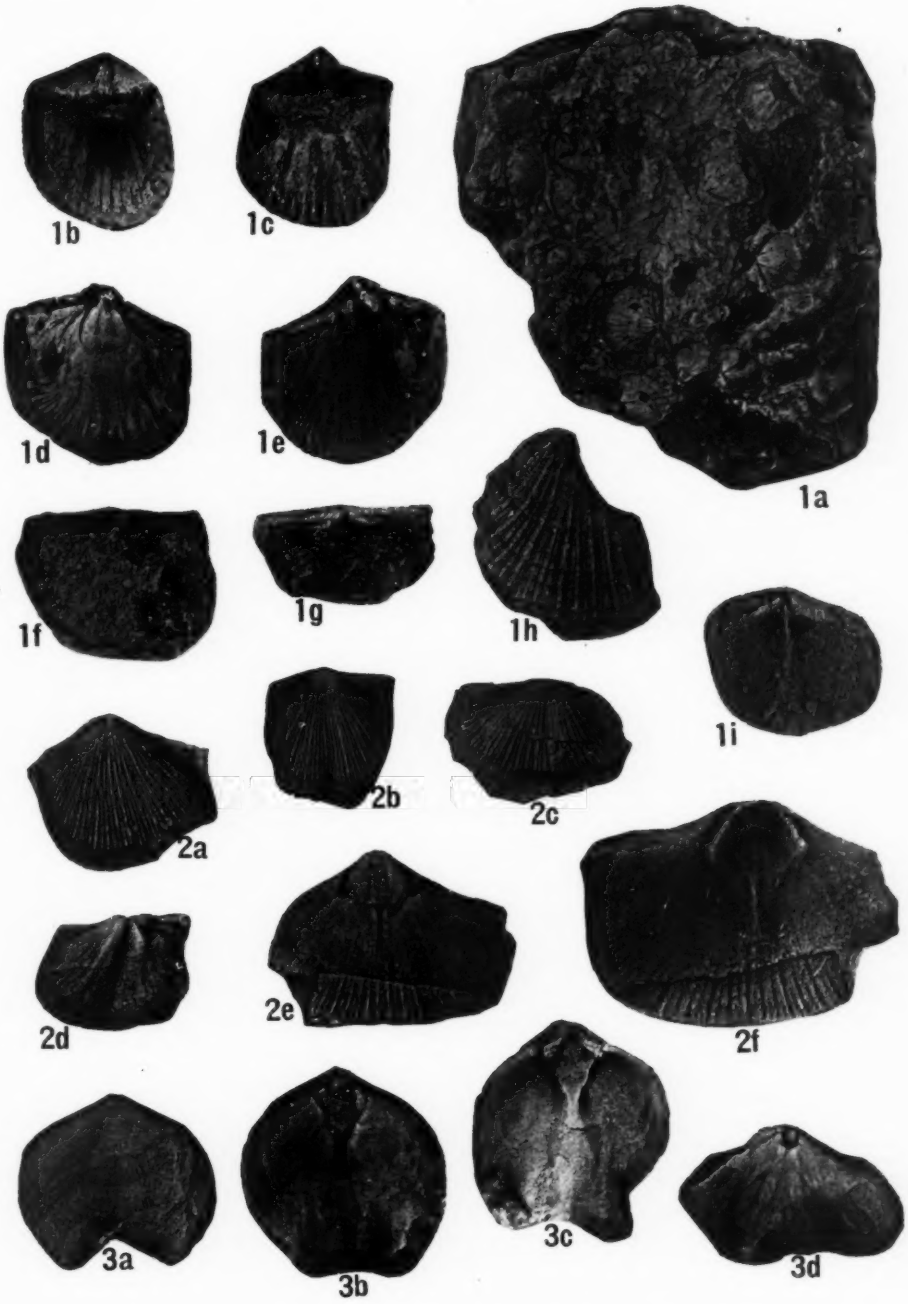
3a—Rubber impression of natural mold of ventral exterior of the holotype, ×2. (Mold of T. G. S. 74X2, B.)

3b—Holotype. Natural internal mold of ventral valve showing impression of spondylium, ×2. (T. G. S. 74X2, A.)

3c—Rubber mold of holotype, ventral valve showing open delthyrium, widely divergent teeth, spondylium and broad low septum, ×2. (Mold of T. G. S. 74X2, A.)

3d—Natural internal mold of dorsal valve showing impressions of lamellae, ×2. (T. G. S. 74X2, C.)

Locality. Junee, on Tyenna River, Tasmania.



Brown, Ordovician Brachiopods from Tasmania

Superfamily CLITAMBONACEA
Schuchert, 1929
Family TRITOECHIIDAE Ulrich
and Cooper, 1936

ULRICH, E. O., and COOPER, G. A., Jour. Paleontology, Vol. 10, no. 7, p. 624.

Subfamily TRITOECHIINAE Ulrich
and Cooper, 1936
Genus TRITOECHIA Ulrich and
Cooper, 1936

For generic description see Ulrich and Cooper (1936, p. 624; 1938, p. 160).

TRITOECHIA LEWISI Brown, n. sp.
Plate 9, figures 1a-1i.

The best specimen in the collection (Tas. Geol. Surv. Coll. no. 74X1) is a slab of yellowish mudstone showing about seven separate internal molds of ventral valves and several imperfectly preserved internal molds of dorsal valves. All are of about the same size and appear to belong to the same species. (Pl. 9, fig. 1a).

External characters.—The shell substance is not preserved. The valves are small, 7.5 mm. wide and 8.0 mm. long, semi-elliptical in outline, with a straight hinge line; both valves convex; anterior commissure rectimarginate. The ventral interarea is almost the full width of the shell and is 1.5 mm. high. A narrow convex deltidium is perforated apically by a foramen, as shown by photographs, Plate 9, figs. la-le.

The dorsal interarea is lower than that of the ventral valve; the notothyrium is partly covered by two chilidial plates, as shown by a specimen on the reverse side of the slab (Plate 9, fig. 1i).

No complete specimen is available showing external ornamentation. Portion of a ventral valve on the reverse side of specimen No. 74X1. shows radiating costellae indicating the presence of about 18 primary ribs with a similar number of interstitial ribs and double that number of tertiary costellae (Plate 9, fig. 1h).

The ventral interior shows a deep delthyrial cavity with well defined dental plates, which are divergent near the beak, but which converge slightly towards the anterior to bound the muscular field (Pl. 9, figs. 1d, 1e). Small, strong teeth are present. Scars of muscular attachment occupy nearly one-third of the length of the shell; pear-shaped diductor scars are separated by linear adductor scars.

The dorsal interior shows a shallow notothyrial cavity; widely divergent brachiophores and a simple cardinal process supported by a short median ridge, which bifurcates to support the brachiophores (Pl. 9, figs. 1f, 1g, 1i). Adductor scars not noticeable.

Locality.—Bedrock, just above Intersection Point F2 on Tyenna aide of Wherret's Lookout, Currawong Gully, Junee District, Tasmania. (See map, Lewis, 1940, p. 45, pl. 7.)

Holotype.—Tas. Geol. Surv. Coll. 74X1, spec. k. (Pl. 9, fig. 1d). Collector, Eric Karmberg, 1942.

Discussion.—The species shows marked resemblances to some described by Ulrich and Cooper (1938) but does not seem to be specifically identical with any of them. In the proportions length to width it resembles *T. occidentalis* Ulrich and Cooper (1938, pl. 31, figs. 18, 22–26) and *T. quebecensis* Ulrich and Cooper, but if differs in details of external ornamentation, in which it appears to be closer to *T. subaequiradiata* Ulrich and Cooper. *T. lewisi* is possibly the species described and figured by Etheridge (1904).

Named in honor of the late Dr. A. N. Lewis.

(?) TRITOECHIA CAREYI Brown, n. sp.
Plate 9, figures 2a–2f

Material consists of several specimens showing external ornamentation (81C6a, 81C6b, 81C10), and one (8107) showing internal molds of one ventral and one dorsal valve. These appear to be closer to *Tritoechia* than to any other described genus, but there are certain differences that may be generic.

The shells are biconvex, slightly wider than they are long (approx. 11 mm. wide and 9 mm. long); the ventral valve has a high beak and the dorasl valve has a slight sulcus. External ornamentation multicostellate; there are about 40 primary costellae and an equal number of interstitial costellae (Pl. 9, figs. 2a, 2b, 2c, 2e).

The ventral valve is semiconical in shape, hinge not quite as wide as the shell. Hinge structures obscure; interarea apsacline; anterior commissure rectimarginate. Delthyrial cavity deep; divergent dental

plates bound the sides but not the anterior margins of the muscular field, which extends less than one-third of the distance to the anterior margin of the shell; diductor muscle scars tear-shaped, adductor scars linear. A short median septum rises from the anterior edge of the muscle scar area (Pl. 9, figs. 2e, 2f).

The interior of the dorsal valve shows a broad median septum, which bifurcates to support the socket-plates. Cardinal process simple. The specimen is distorted by crushing (Pl. 9, fig. 2d).

Locality and Horizon.—Trilobite Bed, Junee, on Tyenna River, 65 miles west of Hobart, Tasmania.

Holotype.—Tas. Geol. Surv. Coll., No. 81C7. (Pl. 9, fig. 2e). Collector, Dr. S. W. Carey, 1945.

Discussion.—This species differs from *Tritoechia lewisi* in external ornamentation and in the shape of the valves. The internal characters of the dorsal valves of the available material appear to be similar, but the interiors of the ventral valves differ in the shape of the muscle scars, the position of the dental plates and the presence in *T. careyi* of a median septum, anterior to the muscle field. The characters of the ventral interiors may indicate generic differences, but the material available is considered to be insufficient for the erection of a new genus.

It is possible that this species is the one figured by Kobayashi (1940, pl. 11, fig. 1) as *Orusia* (?).

Suborder SYNTROPHIOIDEA Ulrich and Cooper, 1936
Family SYNTROPHOPSIDAE Ulrich and Cooper, 1936
Genus SYNTROPHOPSIS Ulrich and Cooper, 1936

For generic description see Ulrich and Cooper (1936, p. 630; 1938, p. 231).

SYNTROPHOPSIS KARMBERGI
Brown, n. sp.
Plate 9, figures 3a–3d

Material consists of a cast of one dorsal valve and of external and internal molds of one ventral valve.

Description.—Shell 15.0 mm. wide, 13.5 mm. long, with rounded outline; valves unequally biconvex, the dorsal valve having the greater convexity. Hinge narrow, equal to slightly less than half the width of the shell; anterior commissure uniplicate; shell almost smooth, showing only fine concentric growth lines. Ventral valve has a wide shallow sulcus in the anterior part of the shell, tongue elongated and rounded. Interarea high. Dorsal valve with low broad fold, well-defined at its margins.

Ventral Interior. Large open delthyrium, with small, widely divergent teeth at the cardinal margin. Spondylium well-developed extending for about one-fourth of the length of the shell, almost sessile, but supported at the anterior end by a broad shallow median septum.

Dorsal Interior. Notothyrium open, notothyrial cavity deep. Traces of subparallel plates inside the beak of the valve probably represent the brachiophore plates.

Types.—Holotype, Tas. Geol. Surv. Spec. No. 74X2(a). Ventral interior [fig. 3b], with its counterpart, 74X2(b), external mold. Topotype, on same rock specimen as holotype, No. 74X2(c), dorsal valve.

Locality.—Junee, on Tyenna River, Tasmania. Coll. Eric Karmberg, 1942.

Discussion.—The specimens from Tasmania more closely resemble those of *Syntrophopsis magna* Ulrich and Cooper, 1936, in form than any of the other eleven described species, but differ in size, *S. magna* being much larger. The interior of the dorsal valve resembles that of *S. arkansasensis* Ulrich and Cooper, 1938, pl. 51, fig. A7.

Named in honour of E. Karmberg.

GEOLOGICAL AGE

The first estimate of the age of the Florentine Valley beds, which was based mainly on fragmentary remains of trilobites, was made by Etheridge (1904), who wrote: "Without expressing a decided opinion on the subject, there is the possibility that in these Florentine Valley beds we have another Tasmanian Cambrian locality, Upper Cambrian in fact, or at least an horizon *very* low in the Silurian" (i. e. Ordovician of present usage).

Kobayashi's study (1940) of a newer collection of trilobites and gastropods, made by Dr. A. N. Lewis, which he referred to *Asaphopsis* and *Lecanospira* respectively, led him to the conclusion that "the two genera

warrant the Lower Ordovician age of the fauna."

The recognition of the brachiopod genera *Tritoechia* and *Syntrophopsis* now permits of a closer approximation of the age of the beds. Fourteen species of *Tritoechia* from U. S. A. and Canada have been described by Ulrich and Cooper (1938, p. 160). Two of these occur in rocks referred to the Upper Ozarkian. According to the authors "All other occurrences are from strata high in the Canadian period in Alabama, Texas, Pennsylvania, Oklahoma, Nevada, Newfoundland, and Greenland."

Regarding the age of *Syntrophopsis* the same authors state (p. 231)

> So far as known, all but two of the 12 members of this genius are confined to rocks of Upper Canadian age. The two exceptions come from boulders in the Mystic conglomerate, the precise age of which remains to be determined. Perhaps the oldest of the known species is *Syntrophopsis australis* from the Newala limestone of Alabama, the age of which is about middle Upper Canadian.

It is the present opinion of Dr. G. A. Cooper that the Newala limestone, which contains species most closely resembling those of Tasmania, is about Middle Canadian in age, using Canadian in its restricted sense as equivalent to the Lower Ordovician, in a threefold division of the Ordovician system.

The evidence of the brachiopods thus indicates that the Junee beds containing brachiopods and trilobites in Tasmania belong to the middle of the Lower Ordovician, approximately equivalent to the top zone (Be 4) of the Bendigo Series or low in the Chewtonian of the graptolitic succession in Victoria, as described by Harris and Thomas (1938).

MANUSCRIPT RECEIVED APRIL 19, 1947.

REFERENCES

ETHERIDGE, R., JR., 1904, Trilobite remains collected in the Florentine Valley, West Tasmania: Australian Mus. Rec., vol. 5, no. 2, pp. 98–101, Pl. 10.

HARRIS, W. J., and THOMAS, D. E., 1938, A revised classification and correlation of the Ordovician graptolite beds of Victoria: Dept. of Mines, Victoria, Mining and Geological Journal, vol. 1, no. 3, 1938, pp. 62–72.

KOBAYASHI, T., 1940, Lower Ordovician fossils from Junee, Tasmania: Roy. Soc. Tas. Pap. and Proc. (for 1939), pp. 61–66, Pl. 11.

LEWIS, A. N., 1940, Geology of the Tyenna Valley: Roy. Soc. Tas. Pap. and Proc. (for 1939), pp. 33–59, Pls. 7–10.

ÖPIK, A., 1934, Uber Klitambonitiden. Acta et Comment., Universit. Tartuensis (Dorpatensis) A XXVI5.

STRZELECKI, P. I. DE, 1845, Physical description of New South Wales, and Van Diemen's Land. London. 1845.

TEICHERT, C., 1947, Early Ordovician cephalopods from Adamsfield, Tasmania: Journ. Paleontology, vol. 21, pp. 420–428, pl. 58.

ULRICH, E. O. and COOPER, G. A., 1936, New species and genera of Ozarkian and Canadian Brachiopods. Jour. Paleontology, Vol. 10, no. 7, pp. 616–631.

ULRICH, E. O., and COOPER, G. A., 1938, Ozarkian and Canadian Brachiopoda. Geol. Soc. America, Special Paper, no. 13, 1938.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 40–47, PLS. 10–13, JANUARY 1948

UPPER DEVONIAN COMPOUND TETRACORALS FROM THE MARTIN LIMESTONE

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ABSTRACT—The compound tetracorals that form the silicified reef in the upper part of the Martin limestone in southeastern Arizona are described and illustrated. The fauna includes two species of *Synaptophyllum*, one of which is new; two new species of *Spongophyllum;* three species of *Hexagonaria*, of which two are new, two species and one new variety of *Pachyphyllum*, and the new genus *Tabellaephyllum* with one new species.

THE Upper Devonian Martin limestone crops out in various localities in southeastern and south-central Arizona. Its thickness varies from 250 to 350 feet. In the southeastern part of the state the formation is a fairly pure limestone but it becomes increasingly arenaceous and argillaceous toward the northwest and thins out near the center of the state. In the majority of outcrops a distinct silicified reef composed of colonial tetracorals is present in the upper part of the formation. In the Santa Catalina Mountains area this reef occurs about fifteen feet below the top. Some very well preserved specimens have been collected from the reef in different localities and stored in the U. S. National Museum, in which institution the type material of this paper has been deposited.

I wish to thank Dr. G. A. Cooper of the U. S. National Museum for permission to borrow and section the specimens.

The following is a list of the localities from which the specimens were collected:

Loc. 1: Limestone hill, just north of Moore's Gulch, western edge of Bisbee quadrangle. USNM loc. no. 477.

Loc. 2: 2.4 miles south of Brown's ranch, western edge of Bisbee quadrangle. USNM loc. no. 481.

Loc. 3: Abrigo Canyon, 2 miles west-southwest of Bisbee. USNM loc. no. 484.

Loc. 4: Southwest front of ridge between Black Gap and Gold Hill, Bisbee quadrangle. USNM loc. no. 490.

Loc. 5: Deer Creek Valley, near head, 13 miles south of San Carlos. USNM loc. no. 499.

Loc. 6: Dragoon Mountains, Cochise County. USNM loc. no. 507.

Loc. 7: Stratton Canyon, Tucson quadrangle. USNM loc. no. 547.

Loc. 8: Coral Ridge, Santa Catalina Mountains, Pima County. USNM loc. no. 551.

Loc. 9: Pepper-sauce Canyon, Tucson quadrangle. USNM loc. no. 561.

SYSTEMATIC DESCRIPTIONS

PHYLUM COELENTERATA
CLASS ANTHOZOA
ORDER TETRACORALLA
Family COLUMNARIIDAE
Subfamily SPONGOPHYLLINAE
Genus SPONGOPHYLLUM Edwards and Haime

Spongophyllum EDWARDS and HAIME, 1851 (3), p. 425.

Genotype: By monotypy, *S. sedgwicki* Edwards and Haime, 1851, p. 425. Devonian: Torquay, Devonshire, England.

Generic description.—Phaceloid, subcerioid, and ceriod corals composed of cylindrical, subpolygonal, or polygonal corallites. Septa of two orders, major and minor of which the former are of variable length and the latter short or lacking. The septa are thin and are separated from the peripheral wall by a small, irregularly developed lonsdaleioid dissepimentarium. The tabularium is composed of tabulae that are usually large and complete. The peripheral dissepimentarium is composed of a single row of vertically disposed, elongated dissepiments. The dissepiments may overlap or double up in certain areas and may be discontinuous in others.

SPONGOPHYLLUM MARTINENSE
Stumm, n. sp.

Plate 11, figures 9, 12; plate 12, figure 6

Description.—Corallum phaceloid to subcerioid, composed of corallites that are rounded to subpolygonal in outline. Exteriors with a heavy annulated epitheca through which vertical interseptal striae are visible. Corallites vary from 4 mm. to 10 mm. in diameter and are often oval in shape. In traverse section a lonsdaleioid dissepimentarium of variable width is present in the large corallites but is intermittently developed or absent in those of smaller size. Radially arranged septa extend from the inner margin of the dissepimentarium. The major average 1 mm. in length and the alternate minor about one-half as long. The septa vary in number from 34 to 40. In the longitudinal section the tabulae are complete, horizontal, and spaced at an average distance of 1 mm. apart. The dissepimentarium is composed of a single row of large, elongate, vertically directed dissepiments, each overlapping the one previously formed. They are intermittently developed so that in certain areas the tabulae reach to the periphery.

Remarks.—The species is most nearly related to *S. semiseptatum* Schlüter, 1881 (12), p. 95, pl. 9, figs. 1–3 as far as structural pattern is concerned. *S. semiseptatum* occurs in the Middle Devonian of the Eifel District, Germany and differs from *S. martinense* in having more closely set and usually incomplete tabulae and in having a continuous dissepimentarium.

Horizon and locality.—Martin limestone, loc. 5.

SPONGOPHYLLUM BREVISEPTATUM
Stumm, n. sp.
Plate 10, figure 7; plate 11, figure 4;
plate 12, figure 8

Description.—Corallum cerioid, composed of polygonal to subpolygonal corallites varying from 4 mm. to 10 mm. in diameter. Calyxes very deep with almost vertical walls and flat axial regions. The radially arranged septa extend down the calyx walls and terminate along the margins of the flat axial regions. Occasionally a few of the major septa cross the axial region and approach the axis. In transverse section the corallites are either polygonal or subpolygonal with rounded margins. A wide lonsdaleioid dissepimentarium is usually developed, but in a few of the corallites it is intermittent and the septa may extend to the periphery in a part of the corallite. In the majority of the corallites the septa are very short, extending not more than 0.5 mm. from the inner margin of the lonsdaleioid dissepimentarium. In other corallites the major septa may be as long as 2 mm. and may extend up to one-half the distance to the axis. The septa average 40 in number in the majority of the corallites. In the longitudinal section the tabulae are horizontal, complete and widely spaced at distances averaging 1.5 mm. apart. The dissepimentarium is composed of a single row of large, vertically disposed, elongate dissepiments, each overlapping the one previously formed. It is intermittently developed so that in places the tabulae extend to the periphery.

Remarks.—The species is similar to *S. martinense* and their longitudinal sections are almost identical, but *S. breviseptatum* may be distinguished by its cerioid form and by the shorter major septa.

Horizon and locality.—Martin limestone, loc. 5.

Genus TABELLAEPHYLLUM
Stumm, n. gen.

Generic description.—Compound coralla composed of corallites with polygonal walls. The tabulae are broken up into tabellae, and there are no septa or dissepiments.

Genotype: *Tabellaephyllum peculiaris* Stumm, n. sp.

TABELLAEPHYLLUM PECULIARIS
Stumm, n. sp.
Plate 12, figures 1, 2, 9, 11

Description.—Compound coralla of subhemispherical shape having a flattened distal surface and a base of attachment. The proximal side is very rugose due to repeated rejuvenescence of the corallites. The distal surface shows the calyxes of the polygonal corallites. They vary from 5 mm. to 15 mm. in diameter and are deep and somewhat funnel-shaped with moderately expanding walls. The interiors are filled with blister-like tabellae. The polygonal walls separating the

corallites are distinctly visible. In the transverse section the walls are straight and heavy. They may be tetragonal, pentagonal or hexagonal. The interior of each corallite is filled with tabellae. No septa or septal crests are visible. In the longitudinal section the structures of the tabellae are very clear. They are quite elongate and usually distally arched. Dissepiments appear to be absent although in some corallites the marginal row of tabellae have an overlapping structure suggestive of the marginal dissepiments characteristic of *Spongophyllum*.

Remarks.—I believe that *Tabellaephyllum* is derived from *Spongophyllum* by the total disappearance of the degenerate septa and by the breaking up of the tabulae into distally arched tabellae.

Horizon and locality.—Martin limestone, loc. 1.

Family DISPHYLLIDAE
Subfamily DISPHYLLINAE
Genus HEXAGONARIA Gürich

Hexagonaria GÜRICH, 1896, (6), p. 171.

Genotype: By subsequent designation of Lang, Smith, and Thomas, 1940 (9), p. 69, *Cyathophyllum hexagonum* Goldfuss, 1826 (5), p. 61, pl. 19, figs. 5e–f; pl. 20, figs. 1a–b. The original of pl. 20, figs. 1a–b has been chosen as lectotype. Middle Devonian: Bensberg and Eifel District, Germany.

Generic description.—Cerioid corals with individual corallites separated by polygonal walls. Calyxes usually with an axial pit and a peripheral platform although the platform may be lacking and the calyx funnel-shaped. Septa radially arranged, of two orders, major and minor, of which the former extend into the tabularium and the latter are confined to the dissepimentarium. They may be dilated or lightly to heavily carinate. The dissepimentaria are wide and composed of many rows of horizontal or inclined dissepiments. The tabularia are usually relatively narrow and composed of closely set, complete or incomplete tabulae.

HEXAGONARIA PALMERI (Meek)
Plate 11, figures 10, 11; plate 13, figure 10

Cyathophyllum palmeri MEEK, 1787 (10), p. 33, pl. 2, fig. 2.

Description.—Large subhemispherical corals composed of polygonal corallites with calyxes having an axial pit and a relatively horizontal peripheral platform. Corallites unequal in size, varying from 4 mm. to 12 mm. in diameter. Polygonal walls prominent, not zigzag but often strongly curved. In the transverse section the septa vary from 30 to 38 in number. They are relatively thin and heavily carinate. The major extend to the axes and the minor terminate just within the borders of the tabularia. In the longitudinal section the tabulae are strongly developed, complete and horizontal in the axial region, but each one is deflected downward at its ends to overlap the preceding one. The dissepimentaria are relatively narrow and composed of nearly horizontal, distally arched dissepiments.

Horizon and locality.—Holotype, Martin limestone, Rio Verde, Arizona; hypotype, Martin limestone, loc. 2.

Holotype.—U. S. Nat. Mus. no. 14545.

HEXAGONARIA OCCIDENS Stumm n. sp.
Plate 11, figures 2, 3, 6

Description.—Subhemispherical coralla composed of polygonal corallites varying from tetragonal to hexagonal in outline. The corallites range from 5 mm. to 10 mm. in diameter and their calyxes possess deep axial pits varying from 2 mm. to 4 mm., and

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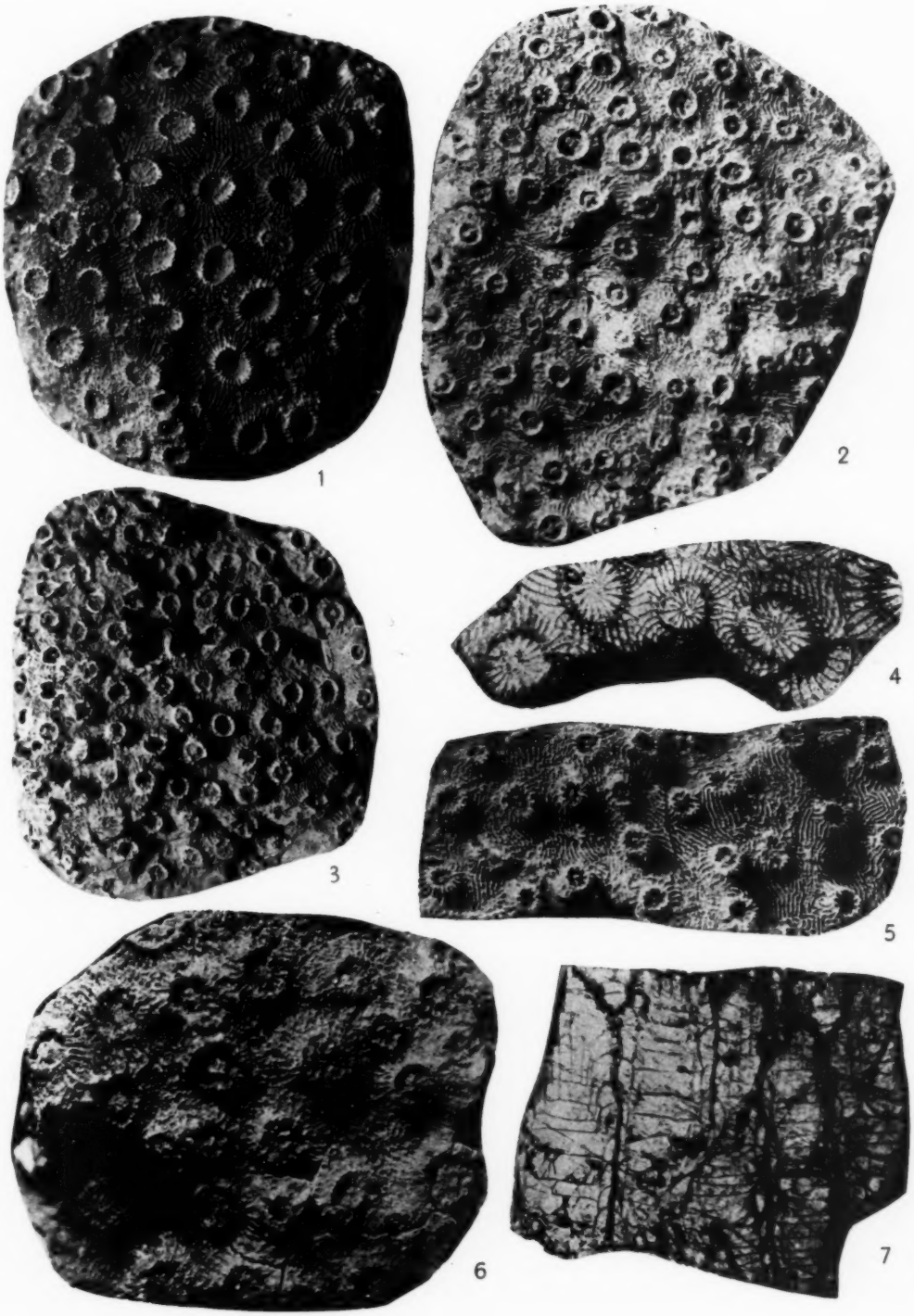
EXPLANATION OF PLATE 10

FIGS. *1, 6—Pachyphyllum woodmani* (White). *1*, distal surface of a typical corallum from the Hackberry group of Iowa. *6*, distal surface of a specimen from the Martin limestone. See also plate 13. (p. 45)

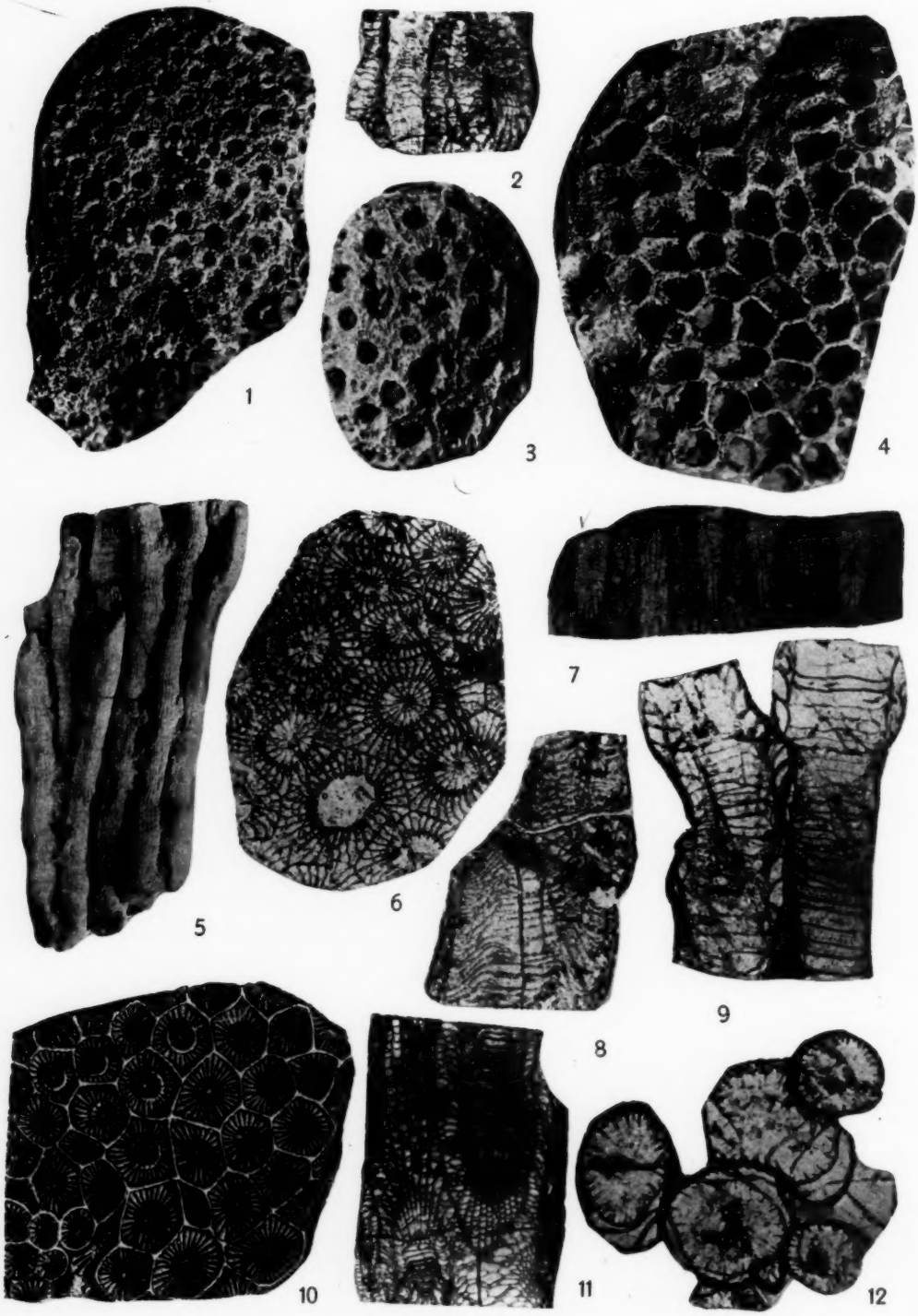
2, 4—Pachyphyllum nevadense magnum Stumm, n. var. *2*, distal surface of holotype, ×1. *4*, transverse section of holotype, ×2.5. (p. 45)

3, 5—Pachyphyllum nevadense (Stumm). *3*, distal surface of hypotype from the Martin limestone. *5*, distal surface of a paratype from the Devils Gate limestone of Nevada, slightly enlarged. (p. 45)

7—Spongophyllum breviseptatum Stumm, n. sp. Longitudinal section of holotype, ×2.5. See also plate 12, figure 8. (p. 41)



Stumm, Martin Limestone Compound Tetracorals



Stumm, Martin Limestone Compound Tetracorals

horizontal peripheral platforms. In the transverse section the septa are radially arranged and vary from 30 to 36 in number. They are slightly dilated and lightly carinate across the dissepimentaria and increase their dilation at the border of the tabularia. The minor septa terminate here and the major, becoming attenuate, continue to the axes. The polygonal walls are heavily defined, not zigzag, and are often curved. In the longitudinal section the tabulae are usually incomplete, rarely complete, and are closely set and typically distally arched.

Remarks.—The species is very similar to *H. inequalis* (Hall and Whitfield) from the Hackberry group of Iowa, but appears to differ in the larger number of septa per corallite and the larger and deeper central pits in the calyxes. Sections of *H. inequalis* have not been published so a closer comparison must wait a revision of that species.

Horizon and locality.—Holotype: Martin limestone, loc. 5; paratype: Martin limestone, loc. 2.

HEXAGONARIA MINUTA Stumm n. sp.
Plate 11, figures 1, 7; plate 13, figure 7

Description.—Subhemispherical to flattened coralla composed of small polygonal corallites with calyxes having an axial pit and a horizontal peripheral platform. The corallites are either pentagonal or hexagonal in outline and vary from 2 to 7 mm. in diameter with the average being about 5 mm. The central pits vary from 1 mm. to 3 mm. in diameter in corallites of different size. In the transverse section the septa are radially arranged and vary from 24 to 28 in number. They are dilated across the dissepimentarium and increase their dilation at the margin of the tabularium. Here the minor septa terminate and the major, becoming very attenuate, continue to the axes. The peripheral portions of the septa have very irregular edges suggestive of carinae reinforced with stereoplasm. The polygonal walls are strong, occasionally fairly straight, but usually distinctly zigzag. In the longitudinal section the tabulae are incomplete, closely set, and usually horizontally disposed. The peripheral dissepimentarium is relatively narrow, and composed of several rows of small to medium sized, horizontally disposed, distally arched dissepiments.

Remarks.—The species is similar to *H. Whitfieldi* Fenton and Fenton (4), p. 57, from the Hackberry group of Iowa, but the corallites in this species are larger and the septa are greater in numbr and more heavily carinate. With regard to size of corallites it is similar to *H. parvula* (Smith), 1945 (13), p. 50, from Upper Devonian limestone of northwestern Canada but the septa in the latter species are all of equal length, much thinner, and have coarse carinae. From *H. occidens* the species may be distinguished by the smaller corallites and the zigzag polygonal walls.

Horizon and locality.—Holotype: Martin limestone, loc. 5; the species is found also in unsilicified condition in great numbers at locs. 1, 2, and 3.

Subfamily PACHYPHYLLINAE
Genus SYNAPTOPHYLLUM Simpson

Synaptophyllum SIMPSON, 1900 p. 212.

Genotype: by original designation, *Diphyphyllum arundinaceum* Billings, 1859 (1),

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EXPLANATION OF PLATE 11

FIGS. *1, 7—Hexagonaria minuta* Stumm, n. sp. *1*, distal surface of holotype, ×1. *7*, longitudinal section of holotype, ×2.5. See also plate 13, figure 7. (p. 43)
2, 3, 6—Hexagonaria occidens Stumm, n. sp. *2*, longitudinal section of paratype, ×2.5. *3*, distal surface of holotype, ×1. *6*, transverse section of paratype, ×2.5. (p. 42)
4—Spongophyllum breviseptatum Stumm, n. sp. Distal surface of holotype, ×1. See also plate 10. (p. 41)
5—Synaptophyllum fasciculum (Meek). Lectotype, ×1. See also plate 12. (p. 44)
8—Synaptophyllum occidens Stumm, n. sp. Longitudinal section of holotype, ×2.5. See also plates 12, 13. (p. 44)
9, 12—Spongophyllum martinense Stumm, n. sp. *9*, longitudinal section of holotype, ×2.5. *12*, transverse section of holotype, ×2.5. See also plate 12. (p. 41)
10, 11—Hexagonaria palmeri (Meek). *10*, Part of Meek's figure of distal surface of holotype, ×1. *11*, longitudinal section of hypotype, ×2.5. See also plate 13. (p. 42)

p. 134. Middle Devonian, Onondaga limestone; Rama's farm near Port Colborne and other localities in Ontario, Canada.

Generic description.—Phaceloid corals composed of narrow, cylindrical corallites often connected by lateral projections of their epithecas. Calyxes with almost vertical walls. Septa carinate and usually dilated peripherally. The major are usually long and the minor always short. Tabulae complete or incomplete, often reinforced by tabellae in the periaxial region. Dissepiments confined to a single peripheral row of highly distally arched horseshoe-shaped forms.

SYNAPTOPHYLLUM FASCICULUM (Meek)
Plate 11, figure 5; plate 12, figures 3, 5, 7, 10

Diphyphyllum fasciculum MEEK, 1877 (10), p. 29, pl. 2, figs. 4, 4a–b.
Synaptophyllum fasciculum STUMM, 1939 (14) p. 62, pl. 7, fig. 9; pl. 8, figs. 10a–b.

Description.—Phaceloid coralla composed of cylindrical corallites varying from 4 mm. to 7 mm. in diameter. Exterior with a thin epitheca through which prominent vertical interseptal ridges are visible and occasionally nodular swellings, causing contact with neighboring corallites, are present. In the trasverse section the septa are radially arranged and vary from 34 to 38 in number. The major approach the axis and the alternate minor are very short, extending less than 1 mm. from the periphery. The septa are carinate and are dilated in their peripheral portions becoming more and more attenuated as they approach the axis. This characteristic gives them a wedge-shaped appearance. In the longitudinal section the tabularium is very wide and composed of tabulae that are usually complete. They are closely set in portions of the corallites but may be as much as 1 mm. apart in others. They may be horizontal or may show downwarping at their peripheral ends. In the latter case they are usually reinforced with periaxial tabellae. A single row of very small, highly distally arched, peripheral horseshoe-shaped dissepiments comprises the dissepimentarium.

Remarks.—The species is very common in the Upper Devonian Devils Gate limestone in the Eureka and White Pine Mining Districts in east-central Nevada. In the Martin limestone a single specimen is known from loc. 3.

SYNAPTOPHYLLUM OCCIDENS
Stumm, n. sp.
Plate 11, figure 8; plate 12, figure 4; plate 13, figure 4

Phaceloid coralla composed of cylindrical corallites averaging 10 mm. in diameter and having calyxes with erect walls and somewhat rounded margins. The septa often extend over the margins of the calyxes and some distance down the exteriors. In the transverse section the septa average about 40 in number and are radially arranged. The major septa extend from 3 mm. to 4 mm. from the periphery and the alternate minor septa are about one-half as long. They are somewhat dilated at the periphery, attenuate axially, and lightly carinate. In the longitudinal section the tabulae are complete or incomplete and are closely set. They are horizontal in the axial region and deflected downward in the periaxial region where they are often reinforced with tabellae. The peripheral dissepimentarium is composed of a single row of globose, distally arched horseshoe dissepiments.

Horison and locality.—Martin limestone, loc. 3.

Genus PACHYPHYLLUM Edwards and Haime

Pachyphyllum EDWARDS and HAIME, 1850 (2), p. lxviii.

Genotype: By original designation: P. *bouchardi* Edwards and Haime, ibid., p. lxviii; 1851 (3), p. 397, pl. 7, figs. 7, 7a–b. Upper Devonian: Ferques, near Boulogne, France.

Generic description.—Astraeoid or plocoid coralla composed of corallites with radially arranged septa that may be confluent, abutting, or may retreat peripherally leaving the corallites united by dissepimental tissue. The septa are always dilated at the margins of the tubularia. This feature produces exsert rims on the distal surface of the corallum at these points. The dissepimentaria and tubularia are separated by a single row of globose, distally arched horseshoe dissepiments.

PACHYPHYLLUM NEVADENSE (Stumm)
Plate 10, figures 3, 5; plate 13, figures 1, 3, 11

Smithia hennahi MEEK, 1877 (not *Astraea hennahi* LONSDALE) (10), p. 32, pl. 2, figs. 6, 6a.
Phillipsastraea hennahi WHITEAVES, 1891, in part (17), p. 204 (excluding specimens from the Middle Devonian of Ontario).
Phillipsastraea verrilli LAMBE, 1901 (not *Smithia verrilli* Meek) (8), pp. 167–168, pl. 14, figs. 5, 5a–b, 6 (excluding specimens mentioned in the text from the Middle Devonian of Ontario).
Phillipsastraea nevadensis STUMM, 1939 (14), p. 66, pl. 7, fig. 13; pl. 8, figs. 15a–b.
Phillipsastraea sp. a MERRIAM, 1940 (11), pl. 14, fig. 1.
Phillipsastraea sp. f MERRIAM, 1940, ibid., pl. 15, fig. 4.
Not *P.* sp. b MERRIAM, 1940, ibid., pl. 15, fig. 2 which is *Phillipsastraea breviseptatum* STUMM; *P.* sp. c MERRIAM, 1940, ibid., pl. 15, fig. 2 which is *Pachyphyllum exiguum* (Smith); or *P.* sp. e MERRIAM, 1940, ibid., pl. 15, fig. 3 which is *Phillipsastraea verrilli* (Meek).
Phillipsastraea macouni SMITH, 1945 (13), p. 41, pl. 20, figs. 4–8; pl. 21, figs. 1–2; pl. 23, figs. 5–6.

Description.—Astraeoid coralla that vary from hemispherical to subhemispherical to discoid in external form. The margins of the tabularia are strongly exsert and project from 2 mm. to 4 mm. above the distal surface. They average about 3 mm. in diameter. The peripheral portions of the septa are of variable length so the tabularia range from a minimum of 5 mm. to a maximum of over 10 mm. apart when measured from their axes. The septa become quite irregular and wavy in their peripheral portions and may be confluent with those of a neighboring corallite or may abut against them. The major septa enter the tabularia and may extend to the axes, forming a small axial boss. In the transverse section the septa vary from 18 to 24 in number. They are strongly dilated across the margins of the tabularia and the minor terminate there while the major, becoming attenuate, extend to or almost to the axes. Outside the tabularia the septa are lightly carinate with small, spinose, offset carinae. The margins of the tabularia have a distinct double-walled appearance between the dilated septa. This is due to the interception of the strongly distally convex marginal row of horseshoe dissepiments. In the longitudinal section the tabularia are distinct and bounded by a single row of horseshoe dissepiments that are small, very globose, and distally convex. The tabulae are complete or incomplete, relatively horizontal, and closely set. In some corallites they are elevated axially and depressed periaxially. In the intertabulate areas the dissepiments are horizontally disposed and elongate.

Remarks.—This species has a large geographic range, having been found in the Martin limestone at almost every listed outcrop; in the Devils Gate limestone of Nevada at the White Pine Mining District, the Eureka District, and the Dutch John Mountain area; in the Upper Devonian limestone along the Peace River in Athabaska and northeastern Alberta; and in the Devonian limestone along the MacKenzie River in the Northwest Territory of Canada. Horizon and locality of hypotype: Martin limestone, loc. 5.

PACHYPHYLLUM NEVADENSE MAGNUM
Stumm, n. var.
Plate 10, figures 2, 4

Phillipsastraea sp. MERRIAM, 1940 (11), pl. 15, fig. 4.

Description.—Hemispherical coralla similar to *P. nevadense* with the exception that the tabularia are larger, ranging up to 5 mm. in diameter, and that there are a greater number of septa, varying from 28 to 32. In all other respects the variety is similar to typical *P. nevadense.*

Horizon and locality.—Holotype: Martin limestone, loc. 1. The species is known also from loc. 5.

PACHYPHYLLUM WOODMANI (White)
Plate 10, figures 1, 6; plate 13, figures 2, 5, 6, 8, 9, 12

Smithia woodmani WHITE, 1870 (16), p. 188.
Pachyphyllum woodmani HALL and WHITFIELD, 1873 (7), p. 239, pl. 9, fig. 9.
Pachyphyllum woodmani WEBSTER, 1899 (15), p. 622.
Pachyphyllum woodmani FENTON and FENTON, 1924, (4), p. 46, pl. 7, figs. 1–3; pl. 8, fig. 2; pl. 9, figs. 11–12; pl. 10, fig. 3.
Phillipsastraea woodmani STUMM, 1939 (14), p. 64, pl. 7, fig. 11; pl. 8, figs. 13a–b.
Phillipsastraea sp. g MERRIAM, 1940 (11), pl. 15, fig. 5.

Description.—Subhemispherical astraeoid coralla similar to *P. nevadense* but with

larger corallites, larger tabularia, more numerous and usually noncarinate septa, and having the peripheral ends of the septa usually not quite reaching those of neighboring corallites. The tabularia vary from 5 to 10 mm. in diameter, and are distinctly oblong in some specimens. They are spaced from 8 to 11 mm. apart measured from their axes. The septa vary from 24 to 44 in corallites of different size but the average size corallite contains from 38 to 42. In some corallites the major septa may extend to the axes forming small axial bosses. In the transverse section the septa are dilated and sometimes faintly carinate across the margins of the tabularia. The double-walled character of the margins of the tabularia are clearly shown in the majority of the corallites. The minor septa terminate at these margins, but the major continue in attenuate form to or almost to the axes. The peripheral portions of the septa are typically noncarinate and they may extend to and abut against those of neighboring corallites or be confluent with them; but the majority terminate just before reaching that point, leaving very narrow areas occupied only with dissepiments. In the longitudinal section the tabularia are bounded with a single series of very small, globose, distally convex horseshoe dissepiments. The tabulae are complete or incomplete and are characteristically elevated and mixed with septal ends in the axial region and slightly depressed in the periaxial region. In the intertabulate areas the dissepiments are horizontally disposed, elongate, and distally convex.

Remarks.—This species also has a wide geographic range, being known from the Hackberry group of Iowa; the Devils Gate limestone of Nevada at the White Pine Mining District and at the Eureka District; and from the Martin limestone. The species has not been reported from western Canada.

Horizon and locality.—Hypotype: Martin limestone, loc. 1.

REFERENCES

(1) Billings, E., 1859, On the fossil corals of the Devonian rocks of Canada West: Canad. Jour. Industry, Sci. Art., n. s., vol. 4.
(2) Edwards, H. M. and Haime, J., 1850–55, A monograph of the British fossil corals.
(3) Edwards, H. M. and Haime, J. 1851, Monographie des Polypiers fossils des Terrains palaeozoïques: Mus. Hist. Nat. Paris. Arch., vol. 4.
(4) Fenton, C. L. and Fenton, M. A., 1924, The stratigraphy and fauna of the Hackberry stage of the Upper Devonian: Univ. Michigan Contr. Mus. Geol. vol. 1.
(5) Goldfuss, G. A., 1826, Petrefecta Germaniae, vol. 1.
(6) Gürich, G., 1896, Das Palaeozoicum des Polnischen Mittelgebirges: Verh. Russ.-Kais. Min. Gesellsch. St. Petersburg, ser. 2, vol. 32.
(7) Hall, J. and Whitfield, R. P., 1873, Descriptions of new species of fossils from the Devonian Rocks of Iowa: 23rd. Ann. Rept. N. Y. State Cab. Nat. Hist.
(8) Lambe, L. M., 1901, A revision of the genera and species of Canadian Palaeozoic corals: Geol. Surv. Canada, Contr. Canadian Paleont., vol. 4, pt. 2.
(9) Lang, W. D., Smith, S., and Thomas, H. D., 1940, Index of Palaeozoic Coral Genera.
(10) Meek, F. B., 1877, Paleontology: U. S. Geol. Expl. 40th Parallel, vol. 4.
(11) Merriam, C. W., 1940, Devonian stratigraphy and paleontology of the Roberts Mountains region, Nevada: Geol. Soc. America, Spec. Paper no. 25.
(12) Schlüter, C., 1881, Über *Callopora eifelensis* und *Spongophyllum semiseptatum:* Naturhist. Verh. Vereines Rheinlande u. Westfalens, vol. 38.

EXPLANATION OF PLATE 12

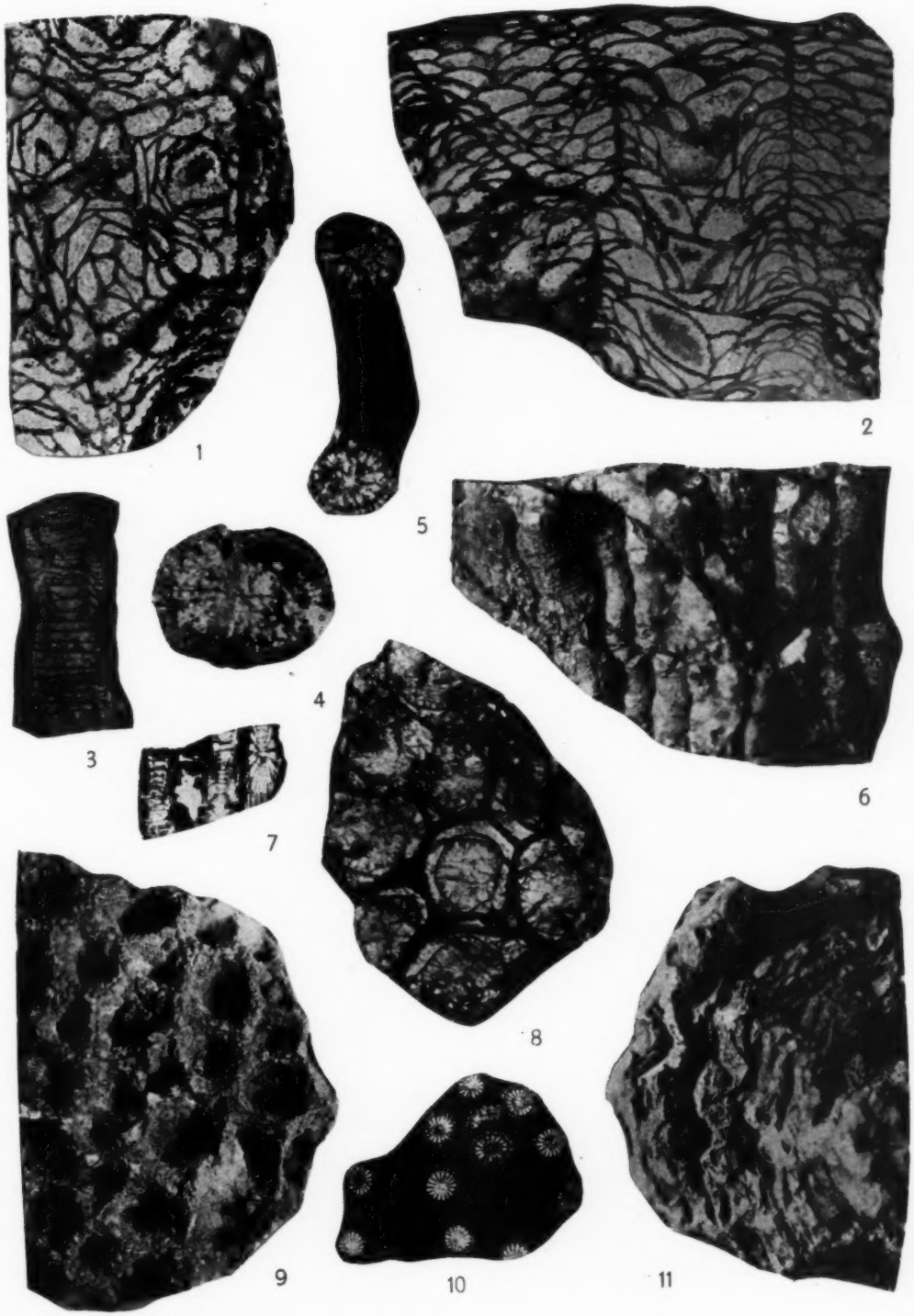
FIGS. *1, 2, 9, 11—Tabellaephyllum peculiaris* Stumm, n. sp. *1*, transverse section of holotype, ×2.5. *2*, longitudinal section of holotype, ×2.5. *9*, distal surface of holotype, ×1. *11*, proximal surface of holotype, ×1. (p. 41)

3, 5, 7, 10—Synaptophyllum fasciculum (Meek). *3*, longitudinal section of a specimen from the Martin limestone, ×2.5. *5*, transverse section of the same specimen as fig. 3. *7*, longitudinal section of a specimen from the Devils Gate limestone, ×1. *10*, transverse section of the same specimen as fig. 7. (p. 44)

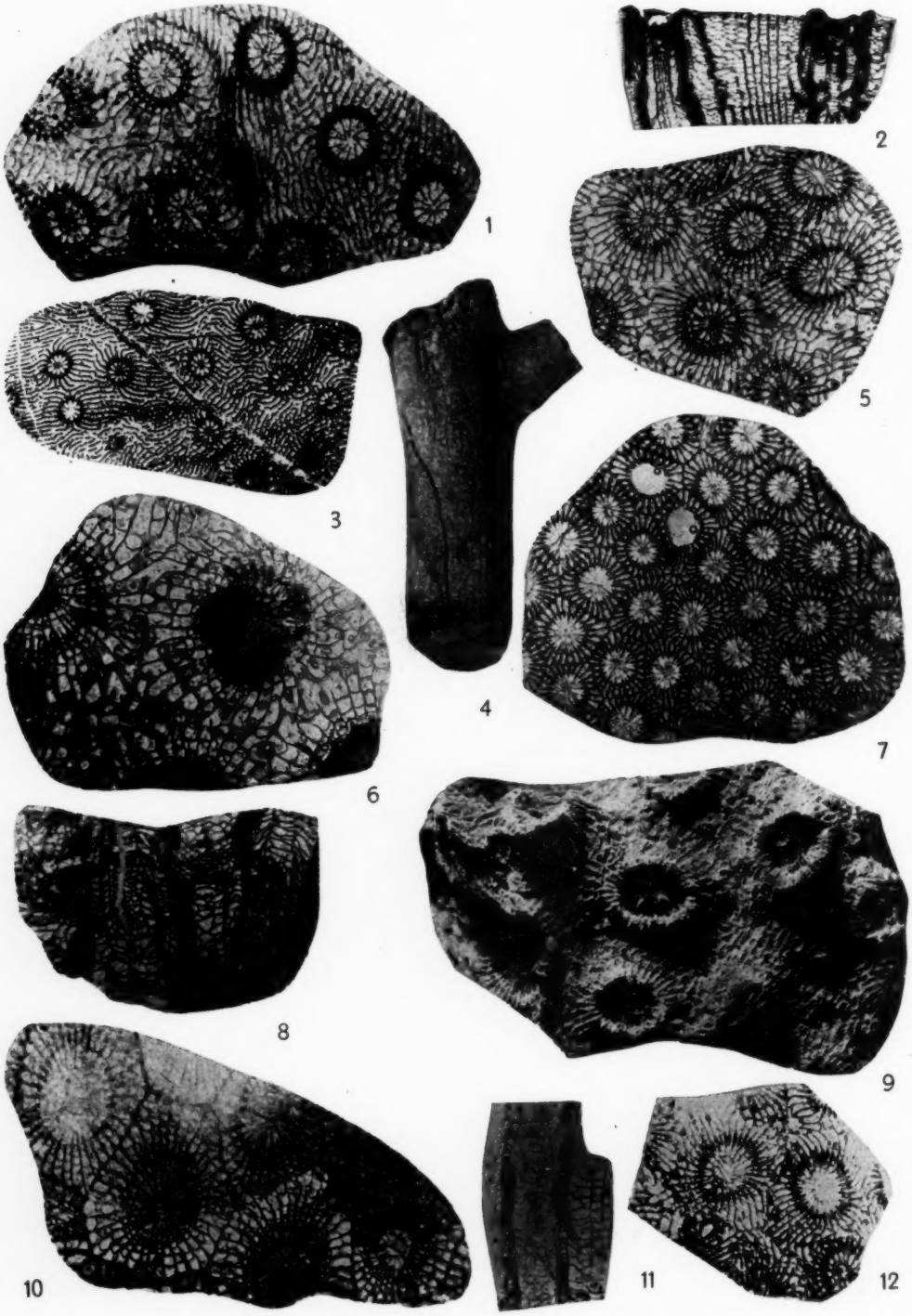
4—Synaptophyllum occidens Stumm, n. sp. Transverse section of holotype, ×2.5. See also plates 11, 13. (p. 44)

6—Spongophyllum martinense Stumm, n. sp. Exterior of holotype, ×1. See also plate 11. (p. 41)

8—Spongophyllum breviseptatum Stumm, n. sp. Transverse section of holotype, ×2.5. See also plates 10, 11 (p. 41)



Stumm, Martin Limestone Compound Tetracorals



Stumm, Martin Limestone Compound Tetracorals

(13) SMITH, S., 1945, Upper Devonian corals of the Mackenzie River region Canada: Geol. Soc. America, Spec. Paper no. 59.
(14) STUMM, E. C., 1940, Upper Devonian rugose corals of the Nevada limestone: Jour. Paleontology, vol. 14, no. 1.
(15) WEBSTER, C. L., 1889, Contributions to the knowledge of the genus *Pachyphyllum*: Am. Naturalist, vol. 23.
(16) WHITE, C. A., 1870, Geol. Iowa, vol. 1.
(17) WHITEAVES, J. F. 1891, Canada, Geol. Surv. Contr. Canadian Palaeont. vol. 1.

MANUSCRIPT RECEIVED JANUARY 6, 1947

EXPLANATION OF PLATE 13

FIGS. *1, 3, 11—Pachyphyllum nevadense* (Stumm). *1*, transverse section of hypotype from the Martin limestone. *3*, transverse section of paratype from the Devils Gate limestone. *11*, longitudinal section of hypotype from the Martin limestone. All ×2.5. See also plate 10. (p. 45)

2, 5, 6, 8, 9, 12—Pachyphyllum woodmani (White). *2, 5*, longitudinal and transverse sections of a typical specimen from the Hackberry group of Iowa, ×1.5. *6, 8*, transverse and longitudinal sections of a hypotype from the Martin limestone, ×2.5. *9*, distal surface of a hypotype from the Devils Gate limestone, ×1.5. This variety has more strongly exsert rims than the typical forms. *12*, transverse section of hypotype from the Devils Gate limestone, ×1.5. (p. 45)

4—Synaptophyllum occidens Stumm, n. sp. Exterior of holotype, ×1.5. See also plates 11, 12. (p. 44)

7—Hexagonaria minuta Stumm, n. sp. Transverse section of holotype, ×2.5. See also plate 11. (p. 43)

10—Hexagonaria palmeri (Meek). Transverse section of hypotype, ×2.5. See also plate 11. (p. 42)

JOURNAL OF PALEONTOLLGY, VOL. 22, NO. 1, PP. 48–59, PLS. 14, 15, JANUARY 1948

ADDITIONS TO THE DEVONIAN CONODONT FAUNAS OF WESTERN NEW YORK

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ABSTRACT—Since the publication in 1926 of Ulrich and Bassler's classic study of Devonian conodonts from western New York, several thousand additional specimens have been collected in the same region. The best of these constitute the basis for the present report. They amplify our knowledge of many previously known forms, and, in addition, thirteen new species are represented.

WESTERN New York is the classical area of this hemisphere for the study of conodonts. Although a few Ohio specimens were illustrated (but not described) by Newberry in 1875 and a brief note on conodonts was published by Ulrich in 1878, the first systematic treatment of this group of fossils from North America was that by Hinde in 1879. He illustrated and described numerous specimens from the Devonian of western New York and some from the Ordovician and Devonian of southeastern Canada. In 1887 Clarke commented on the abundance of conodonts in the Devonian of New York, illustrated some specimens from Ontario County, and said that they occurred in "a very thin, pyritized layer of bituminous shale . . . outcropping about 200 feet above the top of the Genesee Shales in the village of Naples." Grabau, in his report on the paleontology of Eighteen Mile Creek, Erie County, gave abridged descriptions of some of Hinde's specimens and figured those that were from the Devonian of New York in the region adjacent to Lake Erie. Grabau and Shimer (1910) in their well-known work on index fossils, included illustrations of Hinde's conodonts. Bryant (1921) made a comprehensive study of a fauna from Hinde's "Conodont bed" at the base of the Genundewa limestone in Erie County. He illustrated approximately 13 plates of conodonts, and 3 of the fish remains which are so abundant in the conodont horizon along Eighteen Mile Creek.

In 1926, Ulrich and Bassler brought out their report on the classification of conodonts and established the basis for present-day conodont study. This report was based on two faunas. One of these, which was presumed to be Lower Mississippian in age, was collected by Ulrich and Bassler from the Hardin sandstone of Tennessee. The other assemblage is Devonian, and it was secured by Hibbard from the basal part of the Attica ("Rhinestreet") shale at Shaleton, in Erie County, New York. Since the 1926 study by Ulrich and Bassler, Hibbard has continued to collect conodonts from the Shaleton location as well as other areas and has published three short reports (1927, 1928, 1942). Altogether, several thousand specimens have been obtained. This present paper is based on some of the more select of these many conodonts. We are illustrating specimens from the Hanover shale, the lower Attica ("Rhinestreet") shale, and the Geneseo shale ("Conodont-bed" of Hinde's report) at the base of the Genundewa limestone just below the *Styliolina* (*Styliola*) bed.

Though it is generally agreed that all of these formations lie very near the boundary between the Middle and Upper Devonian, opinions have varied as to the exact ages of, and terminology which should be used for some of them. The so-called "Rhinestreet" shale in the region of Lake Erie (including the area of our "Rhinestreet" conodont localities) was reported by Chadwick (1923 p. 69) to include at its top the Hatch formation of the Genesee River section. Therefore, he proposed that the term "Attica" shale be used for this western New York stratigraphic unit which is larger than the typical Rhinestreet shale. This terminology

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is accepted in the Devonian correlation by Cooper et al., (1942).

The black shale and the calcareous "Conodont bed" (which yielded the conodonts of Hinde's and Bryant's studies of 1879 and 1921, respectively) at the base of the Genundewa limestone, and the overlying *Styliolina* (*Styliola*) limestone are regarded by the United States Geological Survey as belonging to the Genesee group of the Upper Devonian. Wilmarth (1938, p. 812) states that the Survey in 1936 adopted the term Geneseo shale for the basal formation of the Genesee group, and redefined Geneseo by including in it at the top the Genundewa limestone lentil; the Genundewa limestone lentil was included in the Geneseo shale "because of its small thickness and the similarity of its fauna to that of the Geneseo, and because at some places it consists of several layers" of limestone separated by black shale. However, Cooper et al., place the boundary between the Middle and Upper Devonian at the top of the Geneseo shale—that is, just below the *Styliolina* or Genundewa limestone. They state (p. 1761) that

> the Genundewa or *Styliolina* limestone overlies the Geneseo and is composed almost wholly of tiny shells of the pteropod *Styliolina*. Accumulation of this limestone, even though it is only a foot thick, must have taken considerable time and thus represents a distinct break in black shale deposition. Not only does the Genundewa represent a break in prevailing sedimentation, but it actually contains many new faunal elements—those of the *Manticoceras* zone. It is in the Genundewa limestone that all but one of the goniatites assigned to the "Geneseo" shale appears; it is at this level that the Naples fauna becomes established.

It seems clear, therefore, that according to the interpretation of Cooper et al., the conodonts secured by Hinde and by Bryant from the "Conodont-bed" at the base of the Genundewa limestone came from the top of the Geneseo shale which has been classed as uppermost Middle Devonian (1942, correlation chart). It should be emphasized, however, that whereas the "Conodont bed" of Hinde lies below the Genundewa limestone, *Styliolina* is not wholly confined to the Genundewa. That is, a few specimens of that pteropod are found in the "Conodont bed." Nevertheless, the Genundewa limestone is a distinctly higher horizon than is the "Conodont bed" and there seems to be little doubt that but the latter zone should be regarded as part of the Geneseo shale.

There appears to be general agreement that the Hanover shale is Upper Devonian in age. Chadwick (1935, p. 352) placed it at the top of the Chemung, and Cooper et al., (1942) concurred with this view.

The bulk of our specimens are from the lower Attica shale (Rhinestreet equivalent) exposed in the Acme shale brick quarry at Shaleton, New York. This is the same horizon and locality which yielded the New York Devonian specimens of Ulrich and Bassler's report. All of the conodonts on which this study is based, with the exception of the two representatives of *Polygnathus*, are embedded in indurated black shale. Since this shale has a rather good cleavage, specimens of the plate-like or platform type of conodonts with a high blade in a plane approximately normal to that of the plate or platform (such as *Palmatolepis*) are almost never found intact in this type of preservation. Our two polygnathids came from washings of a weathered portion of the Geneseo shale. It should be stated, however, that representatives of *Ancyrodella*, *Palmatolepis*, and *Polygnathus* are abundant in the lower Attica shale. In addition, specimens belonging to the genus *Icriodus* are not uncommon in that formation. Though platform or plate-like conodonts which are firmly embedded in shale do not lend themselves very satisfactorily to study and other types of conodonts can be effectively studied from only one side, this manner of preservation has the advantage of retaining many fragile specimens intact. That is, the washing and screening processes involved in removing conodonts from weathered shales usually break up the long bars, denticles, cusps, and anticusps of specimens of *Ligonodina*, *Euprioniodina*, etc., with the undoubted result that numerous fragments of diverse genera come to be placed in the somewhat loosely interpreted but convenient genus *Lonchodus*. As we had several thousand specimens from which to choose, we have endeavored to make an asset of these embedded conodonts by illustrating large and delicate individuals which, if occurring loose in a soft shale, would almost certainly be fragmented during the washing

process. Our figured specimens are essentially complete except for the distal portions of a few cusps and denticles.

Noteworthy among the conodonts illustrated in the present report is the large specimen of *Hibbardella multidens*. This individual compares closely with the largest of Ulrich and Bassler's syntypes of the species, which was essentially only an impression in shale. Also, we have three very well preserved representatives of the genotype of *Bryantodus, B. typicus*, which elucidate the characteristics of this species. It should be noted that our specimen of *Ligonodina mucronata*, n. sp., is one of the largest conodonts recorded in the literature. The length of the preserved part of this individual (measured by means of an ocular micrometer) is 3.52 mm., and the impression in the shale of the small missing portion of the bar indicates that this conodont attained a total length of at least 3.74 mm.

Depending on the size of the specimens, two magnifications have been used—one approximately ×25, the other about ×40, as indicated in the plate legends. The types and the figured specimens are in the private collection of Raymond R. Hibbard, Research Associate of the Buffalo Society of Natural Sciences, Buffalo, New York, and will be placed in the Buffalo Museum of Science where similar collections of types from other studies by that author are now located.

We wish to acknowledge the editorial and advisory assistance which has been generously contributed to this project by Professor A. K. Miller. Mr. Howard E. Webster of Iowa City retouched the photographs which accompany our report.

SYSTEMATIC PALEONTOLOGY

BRYANTODUS ATTICAENSIS Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 3

Bar compressed laterally, gently bowed and moderately arched. Anterior and posterior limbs of bar about equal in length. Anterior limb carries about seven denticles which are larger and more closely appressed than are the seven denticles posterior to the cusp. Cusp small, not much larger than largest of the denticles. This specimen is close to *B. hanoverensis*, n. sp. but differs in the lack of an aboral node beneath the place of cusp insertion and the relatively more discrete nature of the denticles of the posterior bar limb.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), along Eighteen Mile Creek near North Evans, New York.

Holotype.—Hibbard Collection, A-16.

BRYANTODUS BASSLERI Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 11

Specimen gently bowed and strongly arched. Anterior bar limb much the longer of the two, and bears about eight short conical discrete denticles. Posterior bar limb has about five denticles somewhat longer than those of anterior limb. Bar only moderately keeled. Cusp relatively large, stout, rounded laterally, sharpened antero-posteriorly and extending aborally across the margin of the bar as a large node. The figured specimen, the holotype of this species, appears to be complete in every detail.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York.

Holotype.—Hibbard Collection, 417.

BRYANTODUS HANOVERENSIS Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 14

Anterior and posterior bar limbs subequal in length. Holotype uparched and gently bowed outward. Denticles on each bar limb number seven, are only partially confluent and all incline posteriorly. Bar and denticles strongly compressed laterally. Cusp large, central on specimen, with moderate-sized node along aboral margin of bar in line with place of cusp insertion. Of the described representatives of *Bryantodus* this species in form appears to be most nearly approximated by *B. stratfordensis* Stauffer known from the Olentangy shale of Ohio and the Sweetland Creek shale of Iowa. Our species differs from the latter in the more equal size of, and the equal number of denticles on, the bar limbs.

Occurrence.—Hanover shale, south branch of Eighteen Mile Creek, about 2 mi. below Clarksburg, New York.

Holotype.—Hibbard Collection, B-2.

BRYANTODUS MULTIDENS Ulrich and Bassler
Plate 15, figure 15

Bryantodus multidens ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, pp. 22–23, pl. 6, figs. 15, 16.
Bryantodus multidens HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 7.
Bryantodus multidens HUDDLE, 1934, Bull. Am. Paleontology, vol. 21, no. 72, pp. 15, 67, pl. 2, figs. 1–?.
——. HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Bar limbs essentially equal in length, prominently keeled both anteriorly and posteriorly. Keel diminishes near midlength of specimen where a small node is present along the aboral-lateral margin of the bar beneath the place of cusp insertion. Denticles small, subcircular in cross section, though closely appressed on the bar. There are about 11 denticles anterior to the cusp and about 15 posterior to it—those anterior of the cusp are somewhat the larger.

Of the several specimens which have been referred to this species, our specimen is closest to the syntype illustrated by figure 16 of Ulrich and Bassler's plate 6. It should also be mentioned that the particular specimen from the Olentangy shale described by Stauffer as *B. olentangiensis* and illustrated by his figure 28 of plate 48 is close to *B. multidens* and may be conspecific with it. Our specimen is exceptionally well preserved and is complete except for the distal tips of two or three denticles.

Occurrence.—The syntypes of this species, and our specimen, came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York. Also recorded from the New Albany shale of Indiana.

Figured specimen.—Hibbard Collection, 38.

BRYANTODUS OBTUSICUSPUS Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 6

——. HIBBARD, 1928, Rocks and Minerals, vol. 3, no. 4, pl. 1, fig. 1.

Bar strongly arched, anterior limb considerably longer than posterior one. The two or three denticles immediately adjacent to the cusp are small and closely appressed. Those situated more distally are larger, and discrete for most or all of their length. There are about nine denticles anterior to the cusp, seven posterior. The most distinctive feature of this form is the short and very stout cusp. Of the described species of *Bryantodus* our holotype is perhaps closest to *B. brachyodontus* Miller and Youngquist from the type section of the Sweetland Creek shale in Iowa, but differs from that species in the relative length of the two bar limbs. That is, in our species the anterior bar limb is much the larger and longer, whereas in *B. brachyodontus* the reverse is true.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York.

Holotype.—Hibbard Collection, 273.

BRYANTODUS ROBUSTUS Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 1

Bar limbs unequal in length, anterior limb much larger than posterior one. Denticles of anterior portion of anterior bar limb very large, but decreasing in size more or less progressively posterior toward the cusp. At least one denticle near the anterior end of specimen is as large if not larger than the cusp. Denticles of posteriorly bar five or possibly six in number; there are nine denticles anterior to cusp with ultimate anterior denticle of figured specimen very incomplete. All denticles somewhat compressed laterally, partially confluent, and all incline posteriorly at a slight angle. Bar produced laterally to form a pronounced flange along at least the outer (figured) side of the specimen. Aborally, the bar is keeled, particularly anteriorly.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York.

Holotype.—Hibbard Collection, 29.

BRYANTODUS TYPICUS Ulrich and Bassler
Plate 15, figures 4, 9, 12

Bryantodus typicus ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, pp. 16, 21–22, fig. 4, nos. 11, 12; pl. 5, figs. 11, 12.
Bryantodus typicus HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 8.
Bryantodus sp. HIBBARD, 1928, Rocks and Minerals, vol. 3, no. 4, pl. 1, fig. 5.

Bryantodus typicus BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 243.

The type specimens on which this species, the genotype of *Bryantodus*, is based are incomplete in detail. Reconstructions of these types by Ulrich and Bassler in their figure 4 were apparently based in part on impressions in shale, and in part postulated. The collection we are studying contains three specimens, all of which are indeed well preserved and are almost certainly conspecific with the genotype. The individual represented by our figure 4 is similar to that illustrated by Ulrich and Bassler's number 11 of figure 4 and plate 6, figure 12. Our essentially complete specimen indicates that Ulrich and Bassler's tentative completion (fig. 4, no. 11) of this specimen was very well done. Our figure 12 is similar to figure 11, plate 6, and figure 4, number 12 of the genotype. The specimen illustrated by our figure 9, though possessing 5 rather than 4 denticles on the posterior bar limb, is also close to Ulrich and Bassler's figure 4, number 12, and plate 6, figure 11, and appears to be well within the limits of the type species of the genus.

Occurrence.—All our specimens as well as those described by Ulrich and Bassler came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimens.—Hibbard Collection, 31 (fig. 4), 514 (fig. 9), 436 (fig. 12).

BRYANTODUS ULRICHI Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 8

Specimen gently bowed outward and strongly arched. About eight denticles are present posterior to the cusp, about seven anterior. They are short, stout, rounded laterally and partially confluent. Cusp also rounded laterally and sharpened anteriorly and posteriorly. Bar strongly produced laterally, at least on outer (figured) side of holotype, to form a wide flange.

Occurrence. Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York.

Holotype.—Hibbard Collection, 353.

EUPRIONIODINA DEFLECTA Ulrich and Bassler
Plate 14, figure 1

Euprioniodina deflecta ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, pp. 16, 29, fig. 4, no. 14; pl. 3, figs. 11, 12.
Euprioniodina deflecta HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 10.
Euprioniodina deflecta BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 240, pl. 93, fig. 66.

Though only the proximal portion is retained, the presence of a prominently denticulated anticusp is clearly indicated and the specific reference of our specimen seems certain. The denticles number eight, are relatively large, laterally compressed and are discrete to the point of junction with the bar. The cusp is stout and inclines anteriorly at a moderate angle. The bar is somewhat compressed laterally, particularly toward the posterior end. In all these details the specimen under consideration is in close agreement with the illustrations and description of the genosyntypes.

Occurrence.—Our specimen as well as the types came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimen.—Hibbard Collection, 515.

EUPRIONIODINA MAGNIDENS Youngquist, Hibbard and Reimann, n. sp.
Plate 14, figure 13

The chief characteristic of this specimen is its exceptionally large size and the great development of both the cusp and the anticusp. The latter, which is nearly as stout but not so long as the bar, is not deflected laterally and it bears four short denticles on its distal portion. The bar carries about 14 relatively short, sharp denticles which are partially confluent. The entire specimen is compressed laterally, and near the aboral margin there is a ridge-like lateral thickening. Neither the denticles nor the cusp or anticusp appear to be "inserted" into their respective bases for the whole of the specimen is composed of a uniformly hued ivory colored material, making it stand out exceptionally well in the black shale matrix in which it is embedded.

Occurrence.—Lower Attica shale (Rhine-

street equivalent), Acme shale brick quarry Shaleton, New York.

Holotype.—Hibbard Collection, 450.

EUPRIONIODINA PERANGULATA Ulrich and Bassler
Plate 15, figure 5

Euprioniodina perangulata ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 30, pl. 3, fig. 10.
Euprioniodina perangulata HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 10.
Euprioniodina perangulata HUDDLE, 1934, Bull. Am. Paleontology, vol. 21, no. 72, pp. 14, 52–53, pl. 11, fig. 5.

Anticusp long—about two-thirds the length of the bar, finely denticulate, slightly sinuous. Cusp short, rounded laterally, sharpened antero-posteriorly, inclined anteriorly. Bar relatively slender, bears about 12 short sharp rounded denticles which are discrete to the place of junction with the bar. Aboral margin of bar slightly attenuate to form a keel which is best developed posteriorly.

The denticles on the anticusp as well as on the bar of our specimen are more closely spaced than in the holotype of this species, but they are less crowded than on the specimen illustrated by Huddle. In angle of inclination of the bar to the anticusp and to the cusp, and in general physiognomy all three specimens are indeed similar. Our specimen is perhaps closest to the form from the lower New Albany shale.

Occurrence.—Our specimen as well as the holotype of this species came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York. Huddle's specimen is from the New Albany shale of Indiana.

Figured Specimen.—Hibbard Collection, 607.

HIBBARDELLA ANGULATA (Hinde)
Plate 15, figures 2, 13

Prioniodus angulatus HINDE, 1879, Geol. Soc. London Quart. Jour., vol. 35, p. 360, pl. 15, fig. 17.
Prioniodus angulatus GRABAU, 1899, Buffalo Soc. Nat. Sci. Bull., vol. 6, p. 151, fig. 33D.
Prioniodus angulatus GRABAU and SHIMER, 1910, North American index fossils, Invertebrates, vol. 2, pp. 244, 245, fig. 1537h.
Prioniodus angulatus BRYANT, 1921, Buffalo Soc. Nat. Sci. Bull., vol. 13, no. 2, p. 17.
Hibbardella angulata ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 16, fig. 4, no. 15, pp. 17, 37, pl. 3, figs. 1–4.
Hibbardella angulata HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 11, pl. 5, fig. 31.
Hibbardella angulata BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, pp. 141–142, pl. 11, fig. 15.
Hibbardella angulata HUDDLE, 1934, Bull. Am. Paleontology, vol. 21, no. 72, pp. 16, 21, 22, 78–79, pl. 3, figs. 6, 7; pl. 10, fig. 12.
Hibbardella angulata BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 241, pl. 93, fig. 73.
Hibbardella angulata YOUNGQUIST, 1947, Jour. Paleontology, vol. 21, p. 100, pl. 24, figs. 16, 17; pl. 25, fig. 7.

Our most nearly symmetrical specimen (fig. 2) has five denticles on each bar limb. The cusp is straight and relatively stout. The bar limbs are somewhat compressed laterally and, though curved, form a maximum angle of slightly more than 80°. In all respects it agrees with typical representatives of the species. Figure 13 illustrates a specimen that is somewhat less typical having five denticles on one bar limb and six or seven denticles on the other limb and with a somewhat more acute angle (about 62°) between the bar limbs. It seems closer to *H. angulata*, however, than to any other known form.

Occurrence.—Our specimens came from the lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York. Known also from the Geneseo shale near North Evans, New York, the "Cleveland Shales" (Hinde, 1879, p. 360) of Ohio, the New Albany shale of Indiana, and an Upper Devonian shale 1½ mi. northeast of North Liberty, Iowa.

Figured Specimens.—Hibbard Collection, 347 (fig. 2), 601 (fig. 13).

HIBBARDELLA MULTIDENS Ulrich and Bassler
Plate 15, figure 10

Hibbardella multidens ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 38, pl. 3, figs. 8, 9.
Hibbardella multidens HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 11.
?*Hibbardella* cf. *H. multidens* MILLER and YOUNGQUIST, 1947, Jour. Paleontology, vol. 21, p. 508, pl. 72, figs. 8, 9; pl. 73, figs. 10, 11.

We are illustrating a single well-preserved specimen which is essentially bilaterally symmetrical. There are eight denticles on each bar limb. Long axes of the denticles are approximately normal to the

bar with exception of one or two denticles adjacent to the cusp which distally incline toward the cusp. The cusp is long, somewhat flattened on the outer side and has the "flange at the base of the main cusp" which Ulrich and Bassler (p. 38) remark upon. Angle between the bar limbs is large (about 105°). Our specimen is strikingly similar to one of the syntypes of this species (Ulrich and Bassler, pl. 3, fig. 8) which is essentially known only from an impression in shale.

Occurrence.—Our specimen as well as the syntypes came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York. Incomplete individuals probably referable to this species have been reported from the Sweetland Creek shale in Iowa.

Figured Specimen.—Hibbard Collection, 18.

HINDEODELLA DEFLECTA Hibbard
Plate 14, figure 5

Hindeodella deflecta HIBBARD, 1927, Am. Jour. Sci., 5th ser., vol. 13, pp. 207–208, fig. 4c.
Hindeodella deflecta HUDDLE, 1934, Bull. Am. Paleontology, vol. 21, no. 72, pp. 14, 44–45, pl. 5, fig. 15.
Hindeodella deflecta COOPER and SLOSS, 1943, Jour. Paleontology, vol. 17, p. 170, pl. 28, figs. 27, 34.

This specimen agrees in detail with the holotype of the species described by Hibbard from the Middlesex shale; our Attica shale specimen possesses the characteristic deflection of the bar anterior to the cusp. The denticles immediately posterior to the cusp are relatively small, their size increases progressively posterior on the bar. The angle of inclination of the denticles to the bar becomes more acute posteriorly. The posterior region of the bar is slightly deflected aborally.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York. The holotype of this species came from the Middlesex shale along Eighteen Mile Creek, Erie County, New York. Also reported from the New Albany shale of Indiana and a "Lower Mississippian" shale in Montana.

Figured Specimen.—Hibbard Collection, 354.

LIGONODINA ABNORMIS (Hibbard)
Plate 14, figures 7, 11, 12

Prioniodus abnormis HIBBARD, 1927, Am. Jour. Sci., 5th ser., vol. 13, p. 197, fig. 1c.
Prioniodus spicatus HIBBARD, 1927, Am. Jour. Sci., 5th ser., vol. 13, p. 195, figs. 2a, b.
——. HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Since 1927 a large amount of additional information and material has been assembled concerning the abundant and varied forms of *Ligonodina* that occur in the lower Attica shale of western New York. Prominent in our collection, both in size and abundance, are the somewhat variabe entities three of which we are illustrating. Though minor differences occur in all these specimens, no two being precisely alike in number or size of denticles, sufficient characters are held in common to define the species. They are: anticusp nearly as long or longer than the cusp; both cusp and anticusp are slender, sharp, and slightly to moderately recurved posteriorly. Bar straight or gently arched and very slightly sinuous along its oral margin. Total length of bar, and total length of cusp together with anticusp are approximately equal. Denticles very irregular in development, one, two or three small denticles may be intercalated between adjacent larger ones. Maximum height of denticles is attained about midlength on bar. The holotype of this species, the specimen described by Hibbard in 1927, elucidates these features rather well.

Occurrence.—All the known representatives of this species came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimens.—Hibbard Collection, 449 (fig. 7), 22 (fig. 11), and 555A (fig. 12).

LIGONODINA MUCRONATA Youngquist, Hibbard and Reimann, n. sp.
Plate 14, figure 6

——. HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Bar slender, essentially straight, being only very slightly arched orally, somewhat flattened laterally and apparently rectangular in cross-section. Denticles slender, uniformly inclined posteriorly, small in

anterior region of bar, somewhat larger posteriorly and slightly compressed laterally. Cusp long, slender, compressed antero-posteriorly in its distal half, proximal portion is more nearly rounded in cross section but bears a longitudinal groove along its inner posterior side. Presence of an anticusp clearly indicated but anticusp is not retained on our figured holotype. The preserved denticles are nine in number and impressions in the shale matrix indicate that another small denticle may have been present midway between the cusp and the first preserved denticle, and that the bar terminated posteriorly by the addition of a final curved denticle about the same size as the penultimate denticle which is retained on our figured specimen. Measured with the aid of an ocular micrometer, the length of the preserved portion of this specimen is 3.52 mm. with a total length of 3.74 mm. indicated by the shale impression of the posterior-most denticle.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry Shaleton, New York.

Holotype.—Hibbard Collection, 521.

LIGONODINA MUNDA (Hibbard)
Plate 14, figure 9

Prioniodus mundus HIBBARD, 1927, Am. Jour. Sci., 5th ser., vol. 13, p. 193, fig. 1e, f.
Prioniodus mundus HIBBARD, 1928, Rocks and Minerals, vol. 3, no. 4, p. 118, pl. 1, fig. 6.
——. HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Bar slender, straight or slightly arched, flattened laterally and aborally, gently rounded orally. Denticles number about seven to ten, are widely spaced, rounded, become higher midway on the bar, lower both anteriorly and posteriorly and all incline posteriorly. No small denticles intercalated between adjacent larger ones—that is, there is no alternating series of denticles. Only the proximal portion of the anticusp is retained on the specimen figured. However, impressions in shale of similar specimens indicate a fairly large deflected denticulate anticusp which places these conodonts in *Ligonodina*. The cusp is incomplete distally on our figured specimen.

Occurrence.—Our specimen came from the lower Attica shale (Rhinestreet equivalent) along Eighteen Mile Creek near North Evans, New York. Also known from the same formation at Shaleton, New York.

Figured Specimen.—Hibbard Collection, A-60.

LIGONODINA PECTINATA Ulrich and Bassler
Plate 14, figure 8

Ligonodina pectinata ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, pp. 8, 13, fig. 3, no. 6, pl. 2, figs. 9, 10.
Ligonodina pectinata HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 12.
Ligonodina pectinata BRANSON and MEHL, 1944, *in* Shimer and Shrock, Index fossils of North America, p. 241, pl. 93, fig. 75.

The specimen illustrated by our figure 8 agrees in marked detail with one of the figured (Ulrich and Bassler, pl. 2, fig. 9) type specimens of the genotype. Though the classification of conodonts is admittedly artificial, and species are many times allowed considerable latitude, the degree with which certain specimens such as those under consideration resemble one another indicates that a conodont species can be a very well defined unit.

Occurrence.—Our specimen as well as the figured types came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimen.—Hibbard Collection, 4.

LONCHODINA PECTINELLA Youngquist, Hibbard and Reimann, n. sp.
Plate 14, figure 14

——HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Bar bowed, asymmetrically arched, somewhat compressed laterally—particularly the anterior (shorter) limb, and slightly keeled aborally. The 12 denticles are long, slender, and straight or slightly curved posteriorly. Denticles of anterior bar limb number four and are smaller than those of posterior limb. The figured holotype appears to be complete except for the loss of most of the posterior two denticles and the extreme distal portions of one or two others.

Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry Shaleton, New York.

Holotype.—Hibbard Collection, 555B.

LONCHODINA SUBRECTA Ulrich and Bassler
Plate 14, figures 2, 4

Lonchodina subrecta ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 33, pl. 5, figs. 4, 5.
Lonchodina subrecta HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 14.

Our best specimen (fig. 4) is particularly close to that illustrated by Ulrich and Bassler's figure 5. The bar of our specimen is not quite so sinuous as those of the syntypes but the shape, size and occurrence of denticles on the top of the arch of the bar together with the degree of bar arching are strikingly similar to these features of the types. Some of the details of the form of the specimen represented by our figure 2 are obscurred since the conodont is deeply embedded in slightly metamorphosed shale. However, we have illustrated the portions which could be clearly discerned and they indicate that the specimen is most probably conspecific with the more nearly complete specimen (fig. 4) with which it was found in association.

Occurrence.—Our specimens as well as the syntypes came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimens.—Hibbard Collection, 512 (fig. 2), 663 (fig. 4).

LONCHODINA UNGULA Youngquist, Hibbard and Reimann, n sp.
Plate 14, figure 3

——HIBBARD, 1942, Rocks and Minerals, vol. 17, no. 8, p. 273.

Bar slender, subsymmetrical in development, gently bowed outward and moderately arched. Posterior bar deflected inward at junction with cusp. Denticles thin, rounded, well separated; those anterior to cusp are recurved posteriorly, those posterior incline initially posteriorly. Posterior denticles are four in number and are smaller than the five anterior denticles. The distal portion of the cusp and most of the anteriormost denticle are missing on the figured specimen.

Of the described representatives of *Lonchodina*, this species is perhaps closest to *L. subsymmetrica* Ulrich and Bassler but is not considered conspecific with it inasmuch as Ulrich and Bassler state that their representatives have five denticles posterior to the cusp and usually seven anterior to it. Their illustrated specimens as well as the specimen referred to *L. subsymmetrica* by Huddle (1934) indicate that the greater number of denticles is a means of distinguishing that species from our *L. ungula*.

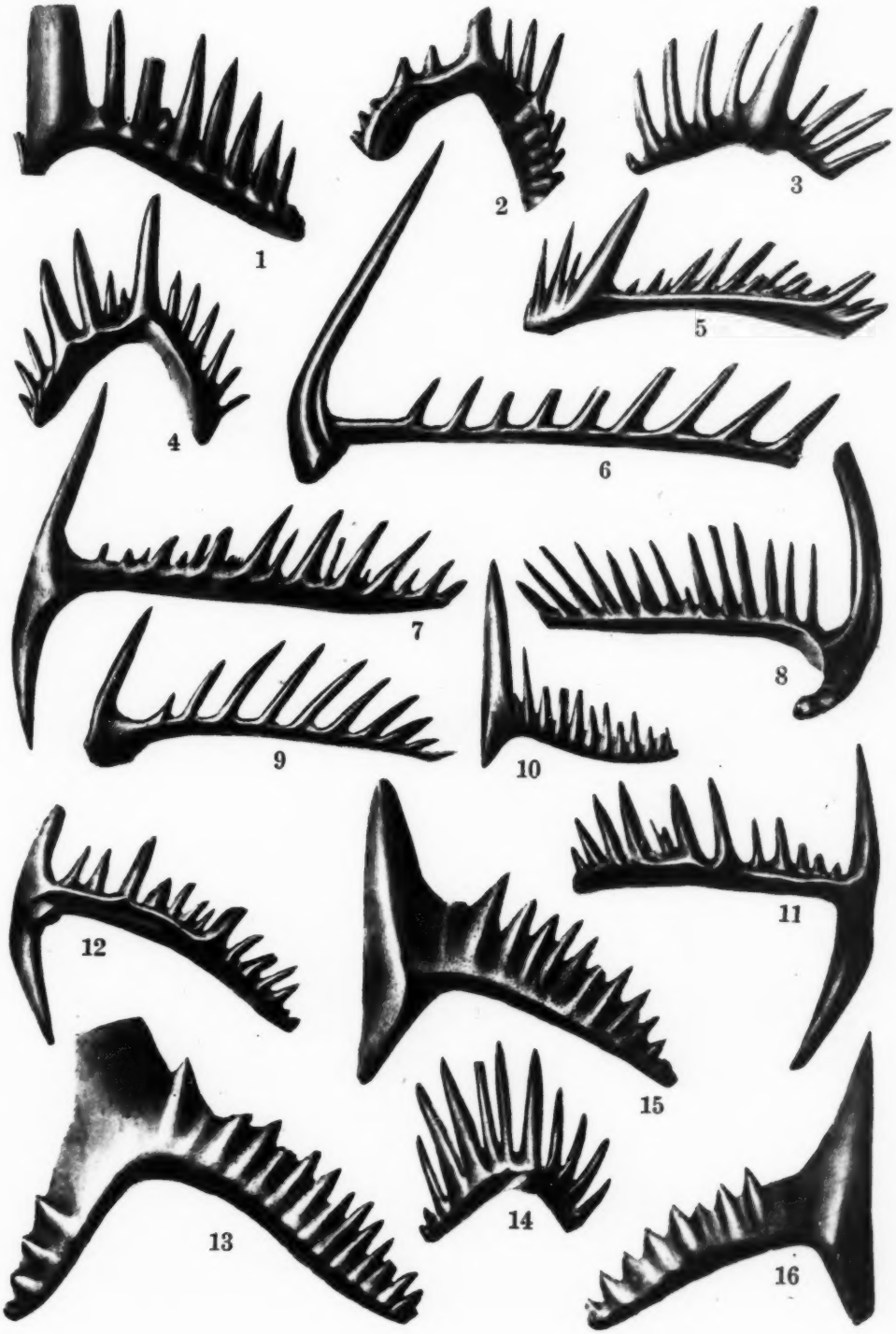
Occurrence.—Lower Attica shale (Rhinestreet equivalent), Acme shale brick quarry, Shaleton, New York.

Holotype.—Hibbard Collection, 422.

EXPLANATION OF PLATE 14

All specimens illustrated on this plate are from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York, with the exception of figure 9. All illustrations are ×25 with the exception of figure 7. Figure 9 is from the lower Attica shale near North Evans, New York. Figure 7 is ×40.

FIGS. *1*—*Euprioniodina deflecta* Ulrich and Bassler. (p. 52)
2—*Lonchodina subrecta* Ulrich and Bassler. See also fig. 4. (p. 56)
3—*Lonchodina ungula* Youngquist, Hibbard and Reimann, n. sp. (p. 56)
4—*Lonchodina subrecta* Ulrich and Bassler. See also fig. 2. (p. 56)
5—*Hindeodella deflecta* Hibbard. (p. 54)
6—*Ligonodina mucronata* Youngquist, Hibbard and Reimann, n. sp. (p. 54)
7—*Ligonodina abnormis* (Hibbard). See also figs. 11, 12. (p. 54)
8—*Ligonodina pectinata* Ulrich and Bassler. (p. 55)
9—*Ligonodina munda* (Hibbard) (p. 55)
10—*Prioniodus undosus* Ulrich and Bassler. (p. 58)
11—*Ligonodina abnormis* (Hibbard). See also figs. 7, 12. (p. 54)
12—*Ligonodina abnormis* (Hibbard). See also figs. 7, 11. (p. 54)
13—*Euprioniodina magnidens* Youngquist, Hibbard and Reimann, n. sp. (p. 52)
14—*Lonchodina pectinella* Youngquist, Hibbard and Reimann, n. sp. (p. 55)
15—*Prioniodus alatus* Hinde. See also fig. 16. (p. 58)
16—*Prioniodus alatus* Hinde. See also fig. 15. (p. 58)



Youngquist, Hibbard and Reimann, New York Devonian Conodonts

Youngquist, Hibbard and Reimann, New York Devonian Conodonts

POLYGNATHUS MESACOSTALIS Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 16

Plate is strongly bowed but only moderately arched. The most distinctive feature of this form is the very pronounced carina which extends the length of the plate and anteriorly merges with the blade. Posteriorly, the carina consists of several large partially discrete nodes but these nodes fuse progressively anteriorly into a short blade-like ridge. The margins of the plate are strongly nodose. Elongate semismooth depressions occur between the carina and the plate margins. The blade is moderately large; the denticles which presumably make up the blade are neither distinct nor discrete, serving only to slightly crenulate the blade orally. Aborally, the holotype bears a moderately well-developed keel. A good-sized escutcheon is present midway beneath the plate and is elongated both anteriorly and posteriorly. Fine concentric growth lines are visible on the plate's aboral surface when properly lighted.

Occurrence.—The "Conodont-bed" at the top of the Geneseo shale directly beneath the Genundewa (*Styliolina*) limestone, at Hinde's locality along Eighteen Mile Creek, near North Evans, New York.

Holotype.—Hibbard Collection, G-56.

POLYGNATHUS PERSULCATA Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 17

Plate narrow, pointed posteriorly; oral surface exhibits strong relief with a stout carina persisting the length of the plate. Anteriorly, the carina consists of large discrete nodes, posteriorly these nodes become somewhat fused and subdued. The inner oral lateral margin of the plate bears six or seven stout ridges which are elongated in a direction approximately normal to the long axis of the plate. The outer lateral margin of the plate bears four or five ridges whose long

EXPLANATION OF PLATE 15

FIGS. *1*—*Bryantodus robustus* Youngquist, Hibbard and Reimann, n. sp. Lower Attica shale, Shaleton, New York. ×40. (p. 51)

2—*Hibbardella angulata* (Hinde). Lower Attica shale, Shaleton, New York. ×25. See also fig. 13. (p. 53)

3—*Bryantodus atticaensis* Youngquist, Hibbard and Reimann, n. sp. Lower Attica shale, along Eighteen Mile Creek near North Evans, New York. ×40. (p. 50)

4—*Bryantodus typicus* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. See also figs. 9, 12. (p. 51)

5—*Euprioniodina perangulata* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. (p. 53)

6—*Bryantodus obtusicuspus* Youngquist, Hibbard and Reimann, n. sp. Lower Attica shale, Shaleton, New York. ×40. (p. 51)

7—*Synprioniodina hanoverensa* Youngquist, Hibbard and Reimann, n. sp. Hanover shale, near Clarksburg, New York. ×40. (p. 58)

8—*Bryantodus ulrichi* Youngquist, Hibbard and Reimann, n. sp. Lower Attica shale, Shaleton, New York. ×25. (p. 52)

9—*Bryantodus typicus* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. See also figs. 4, 12. (p. 51)

10—*Hibbardella multidens* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. (p. 53)

11—*Bryantodus bassleri* Youngquist, Hibbard and Reiman, n. sp. Lower Attica shale, Shaleton, New York ×25. (p. 50)

12—*Bryantodus typicus* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. See also figs. 4, 9. (p. 51)

13—*Hibbardella angulata* (Hinde). Lower Attica shale, Shaleton, New York. ×25. See also fig. 2. (p. 53)

14—*Bryantodus hanoverensis* Youngquist, Hibbard and Reimann, n. sp. Hanover shale, near Clarksburg, New York. ×40. (p. 50)

15—*Bryantodus multidens* Ulrich and Bassler. Lower Attica shale, Shaleton, New York. ×25. (p. 51)

16—*Polygnathus mesacostalis* Youngquist, Hibbard and Reimann, n. sp. "Conodont-bed" at top of Geneseo shale, near North Evans, New York. ×40. (p. 57)

17—*Polygnathus persulcata* Youngquist, Hibbard and Reimann, n. sp. "Conodont-bed" at top of Geneseo shale, near North Evans, New York. ×40. (p. 57)

axes are arranged in a radiating manner. The blade is high, short, twisted laterally and consists of six or seven denticles which are fused essentially to their apices. Aboral surface of plate is strongly keeled medianly with only a small subcircular escutcheon present slightly anterior of midlength. The figured specimen is illustrated by an oral view.

Occurrence.—The "Conodont-bed" at the top of the Geneseo shale directly beneath the Genundewa (*Styliolina*) limestone, at Hinde's locality along Eighteen Mile Creek, near North Evans, New York.

Holotype.—Hibbard Collection, G-57.

PRIONIODUS ALATUS Hinde
Plate 14, figures 15, 16

Prioniodus? alatus HINDE, 1879, Geol. Soc. London Quart. Jour., vol. 35, p. 361, pl. 16, fig. 5.
Prioniodus? alatus GRABAU, 1899, Buffalo Soc. Nat. Sci. Bull., vol. 6, p. 153.
Prioniodus? alatus GRABAU and SHIMER, 1910, North American index fossils, Invertebrates, vol. 2, p. 243.
Prioniodus alatus GRABAU and SHIMER, 1910, North American index fossils, Invertebrates. vol. 2, p. 244.
Prioniodus alatus BRYANT, 1921, Buffalo Soc. Nat. Sci. Bull., vol. 13, no. 2, pp. 15–16, pl. 3, fig. 10; pl. 4, figs. 1–7.
Prioniodus alatus ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 11, pl. 1, figs. 25, 26.
Prioniodus alatus HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 20, pl. 3, fig. 40.
Prioniodus alatus BRANSON and MEHL, 1933, Missouri Univ. Studies, vol. 8, no. 2, p. 134, pl. 11, fig. 13.
Prioniodus alatus HUDDLE, 1934, Bull. Am. Paleontology, vol. 21, no. 72, pp. 14, 21, 37, pl. 1, figs. 1–3.
Prioniodus alatus COOPER, 1939, Jour. Paleontology, vol. 13, pp. 404, 420, pl. 45, fig. 55; pl. 46, figs. 6, 8.
?*Prioniodus* cf. *P. alatus* HASS, 1943, Jour. Paleontology, vol. 17, p. 308.
Prioniodus alatus QUIGLEY, and MEHL and QUIGLEY, 1944, *in* Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 158, pl. 27, figs. 42, 45, 46 [not 43, "47"].
Prioniodus alatus YOUNGQUIST, 1947, Jour. Paleontology, vol. 21, p. 111, pl. 26, fig. 11.

We are illustrating two well preserved specimens of this well known conodont species. The individual shown by figure 15 is complete in all details except for the distal portions of the cusp and the anterior-most and posterior-most denticles. The bar is strongly arched but not appreciably bowed. The denticles are discrete in their apical half and are laterally compressed. The anticusp is large and is sharply deflected aborally but not anteriorly or laterally. The specimen shown by figure 16 also is referable to this species, being particularly close to the individual illustrated by Ulrich and Bassler in 1926 by figure 25 of their plate 1.

Occurrence.—Geneseo and lower Attica shales of New York, the New Albany shale of Indiana, the Snyder Creek shale and the Sylamore sandstone of Missouri, a "Bushberg-Hannibal horizon" in Oklahoma, an Upper Devonian shale near North Liberty, Iowa, and the Sweetland Creek shale of Iowa. Our specimens came from the lower Attica shale (Rhinestreet equivalent) in the Acme shale brick quarry at Shaleton, New York.

Figured Specimens.—Hibbard Collection, 664 (fig. 15), 301 (fig. 16).

PRIONIODUS UNDOSUS Ulrich and Bassler
Plate 14, figure 10

Prioniodus undosus ULRICH and BASSLER, 1926, U. S. Nat. Mus. Proc., vol. 68, art. 12, p. 12, pl. 1, figs. 18–20.
Prioniodus undosus HOLMES, 1928, U. S. Nat. Mus. Proc., vol. 72, art. 5, p. 22.

Denticles of our illustrated specimen are 12 in number including small denticle immediately posterior to cusp. Cusp inclines slightly anteriorly; anticusp small. Bar sinuous—that is, anteriorly the aboral side of the bar is curved convexly orad; posteriorly it becomes convex in an aboral direction. Cusp, denticles and bar compressed laterally but where the denticles join the bar it swells gently to form very small node-like processes. This specimen is particularly close to that figured by Ulrich and Bassler (1926, pl. 1, fig. 19).

Occurrence.—The syntypes of this species as well as our specimen came from the lower Attica shale (Rhinestreet equivalent), Shaleton, New York.

Figured Specimen.—Hibbard Collection, 290.

SYNPRIONIODINA HANOVERENSA Youngquist, Hibbard and Reimann, n. sp.
Plate 15, figure 7

Anticusp only slightly smaller than bar.

Cusp very large, compressed laterally and slightly recurved though inclining posteriorly. Anticusp and bar together with the denticles much compressed laterally to blade-like proportions. Denticles closely appressed and fused for about half their length.

This specimen superficially appears to be related to *Bryantodus*, probably because of the nearly equal development of the anticusp relative to the bar. However, it lacks the "narrow flange-like expansion on both sides [of the base]" (Ulrich and Bassler, p. 21) which characterizes that genus. Except for its marked lateral compression, our specimen could be placed in *Euprioniodina*. In their diagnosis of *Synprioniodina*, Ulrich and Bassler (p. 42) state that it is "more closely allied to *Euprioniodina* the essential difference being the almost complete lateral fusion of the denticles." From this diagnosis our specimen appears to belong in *Synprioniodina*.

Occurrence.—Hanover shale at Cromer's saw mill, along south branch of Eighteen Mile Creek, 2 mi. downstream from Clarksburg, New York.

Holotype.—Hibbard Collection, B-3.

REFERENCES

BRANSON, E. B., 1944, The geology of Missouri: Missouri Univ. Studies, vol. 19, no. 3, pp. 1–535, pls. 1–49.

——, and MEHL, M. G., 1933, A study of Hinde's types of conodonts preserved in the British Museum: Missouri Univ. Studies, vol. 8, no. 2, pp. 133–156, 165–167, pls. 11, 12.

——, and MEHL, M. G., 1934 [1933], Conodonts from the Bushberg sandstone and equivalent formations of Missouri: Missouri Univ. Studies, vol. 8, no. 4, pp. 265–299, pls. 22–24.

BRYANT, W. L., 1921, The Genesee conodonts: Buffalo Soc. Nat. Sci. Bull., vol. 13, no. 2, pp. 1–59, pls. 1–16.

CHADWICK, G. H., 1923, Chemung stratigraphy in western New York [abstract]: Geol. Soc. America, Bull., vol. 34, pp. 68, 69.

——, 1935, Chemung is Portage: Geol. Soc. America, Bull., vol. 46, pp. 343–354.

CLARKE, J. M., 1887, Annelid teeth from the lower portion of the Hamilton group and from the Naples shales of Ontario County, N. Y.: New York State geol., sixth ann. rept. for the year 1886, pp. 30–33, pl. A1.

COOPER, C. L., 1939, Conodonts from a Bushberg-Hannibal horizon in Oklahoma: Jour. Paleontology, vol. 13, pp. 379–422, pls. 39–47.

——, and SLOSS, L. L., 1943, Conodont fauna and distribution of a Lower Mississippian black shale in Montana and Alberta: Jour. Paleontology, vol. 17, pp. 168–176, pls. 28, 29.

COOPER, G. A., *et al.*, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. America Bull., vol. 53, pp. 1729–1793, 1 pl.

GRABAU, A. W., 1899, The paleontology of Eighteen Mile Creek and the lake shore sections of Erie County, New York: Buffalo Soc. Nat. Sci. Bull., vol. 6, pp. 97–390.

——, and SHIMER, H. W., 1910, North American index fossils, Invertebrates, vol. 2, New York, pp. 1–909.

HASS, W. H., 1943, Corrections to the Kinderhook conodont fauna, Little Rocky Mountains, Montana: Jour. Paleontology, vol. 17, pp. 307–309.

HIBBARD, R. R., 1927, Conodonts from the Portage group of western New York: Am. Jour. Sci., 5th ser., vol. 13, pp. 189–208, figs. 1–4.

——, 1928, Western New York conodonts: Rocks and Minerals, vol. 3, no. 4, pp. 117–119, 1 pl.

——, 1942, Conodonts in the Upper Devonian rocks of western New York: Rocks and Minerals, vol. 17, no. 8, pp. 271–276, 1 pl.

HINDE, G. J., 1879, On conodonts from the Chazy and Cincinnati group of the Cambro-Silurian, and from the Hamilton and Genesee-Shale division of the Devonian, in Canada and the United States: Geol. Soc. London Quart. Jour. vol. 35, pp. 351–369, pls. 15–17.

HOLMES, G. B., 1928, A bibliography of the conodonts with descriptions of early Mississippian species: U. S. Nat. Mus. Proc., vol. 72, art. 5, pp. 1–38, pls. 1–11.

HUDDLE, J. W., 1934, Conodonts from the New Albany shale of Indiana: Bull. Am. Paleontology, vol. 21, no. 72, pp. 1–136, pls. 1–12.

MILLER, A. K., and YOUNGQUIST, WALTER, 1947, Conodonts from the type section of the Sweetland Creek shale in Iowa: Jour. Paleontology vol. 21, pp. 501–517, pls. 72–75.

NEWBERRY, J. S., 1875, Descriptions of fossil fishes: Ohio Geol. Survey Report, vol. 2, pt. 2, paleontology, pp. 1–64, pls. 54–59.

SHIMER, H. W., and SHROCK, R. R., 1944, Index fossils of North America: New York and London, pp. 1–837, pls. 1–303.

STAUFFER, C. R., 1938, Conodonts of the Olentangy shale: Jour. Paleontology, vol. 12, pp. 411–443, pls. 48–53,

——, 1940, Conodonts from the Devonian and associated clays of Minnesota: Jour. Paleontology, vol. 14, pp. 417–435, pls. 58–60.

ULRICH, E. O., and BASSLER, R. S., 1926, A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species: U. S. Nat. Mus. Proc., vol. 68, art. 12, pp. 1–63, pls. 1–11.

WILMARTH, M. G., 1938, Lexicon of geologic names of the United States (including Alaska): U. S. Geol. Survey Bull. 896, pts. 1, 2, 2396 pp.

YOUNGQUIST, WALTER, 1947, A new Upper Devonian conodont fauna from Iowa: Jour. Paleontology, vol. 21, pp. 95–112, pls. 24–26.

MANUSCRIPT RECEIVED APRIL 18, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 60–67, PL. 16, 4 TEXT-FIGS., JANUARY 1948

MIDDLE DEVONIAN GONIATITES FROM THE BUCHAN DISTRICT, VICTORIA

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ABSTRACT—The following goniatites are described: *Bactrites howitti*, n. sp., *Bactrites* sp. ind., *Lobobactrites inopinatus*, n. sp., *Lobobactrites* sp. ind., *Gyroceratites desideratus*, n. sp., and an indeterminate anarcestid. The fauna forms three distinct assemblages which are all closely related in age and indicate early Middle Devonian. It is the first goniatite fauna of this age to be described from the Australasian region.

INTRODUCTION

DEVONIAN goniatite faunas are of rare occurrence in Australia. The present writer has previously (1941, 1943) reported on Upper Devonian goniatite assemblages from northwestern Australia, but with the exception of a doubtful *Maenioceras* of late Middle Devonian age, Middle Devonian goniatites were unknown from the Australian continent.

As pointed out by me (1943, p. 169) previous records of Devonian goniatites in eastern Australia are probably all erroneous.[1]

The discovery of a goniatite fauna of early Middle Devonian age in southeastern Australia is therefore of some importance and seems to merit description, although the fauna is small and not particularly well preserved.

All the specimens described in this paper were collected during field work carried out in the Buchan District from May to August 1946, and are now in the Geological Museum of the Mines Department, Melbourne. Thanks are due to Professor E. S. Hills, University of Melbourne, who arranged for the photography of the fossils in his Department, and to the Secretary of the Victoria Mines Department for permission to publish this paper.

[1] In 1943 I pointed out that Stirling in 1881 had recorded a goniatite resembling "*Goniatites marcellensis*" from Bindi, Victoria, but it was not quite correct to say that no goniatite bearing this name had ever been described from North America. The name was used by Vanuxem for a species of "*Goniatites*" which was later transferred to the nautiloid genus *Centroceras* (see Kindle and Miller, 1939, p 52) Stirling's Bindi specimen may therefore have been a nautiloid or else a goniatite of gyroceratitid or agoniatitid affinities.

OCCURRENCE

The new goniatite fauna was collected from various localities in the vicinity of Buchan and Murrindal in northeastern Gippsland, Victoria, where Devonian rocks had long been known to occur, although until recently they had received little detailed attention. The Devonian sediments known as the Buchan series, occur here in an area about eleven miles long and up to five miles wide. They rest conformably on a volcanic series, usually, though not quite appropriately known as the "Snowy River Porphyries," and are preserved, partly through down-faulting, in a tectonic depression in the prophyries.

An account of the stratigraphy of the district will be published later and a brief summary will suffice in this place.

At the base of the sedimentary series is in many places a sequence of tuffs, agglomerates, grits and sandstones, with some interbedded limestone horizons. These beds vary greatly in thickness from a few feet to 200 or 300 feet. They are followed conformably by about 600–700 feet of limestone for which the name Cave Limestone is proposed. This limestone is unfossiliferous (or almost so) in its lower part, but becomes increasingly fossiliferous in its upper two-thirds, the most important fossils being *Campophyllum recessum* Hill and *Spirifer yassensis* de Koninck with which are associated a rich

coral fauna and, in the upper third or so, numerous pelecypods (*Modiomorpha*, *Conocardium*, et al.), nautiloids, and ostracodes. No goniatites have been found in the Cave Limestone.

The Cave Limestone is overlain by a mudstone-limestone series of somewhat complex stratigraphy and up to 1800 feet thick. Immediately overlying the limestone are calcareous mudstones with limestone nodules and discontinuous limestone bands, characterized by an abundance of *Chonetes australis* McCoy. Higher in the sequence the facies differs considerably in different parts of the area. In the southern part, east of Buchan and in the valleys of Taravale and Blowhard Creeks, the facies is predominantly calcareous mudstone which may contain scattered limestone nodules and intercalations of impure limestone beds. The amount of limestone decreases in a southerly direction. In a northerly direction however, the limestone intercalations increase in amount and the beds grade into massive reef limestones with *Favosites*, *Receptaculites*, and stromatoporoids. This change begins in the upper part of the mudstone series and as one goes north from Buchan towards Murrindal successively lower parts of the series change into bedded limestones and reef limestones, until north of Murrindal even the beds with *Chonetes australis* are massively calcareous.

Goniatites have been found in this series in a number of localities (see map, fig. 1).

Locality A is situated at Buchan, immediately south of the bridge over the Buchan River, where *Gyroceratites desideratus* occurs in a bed of irregular hard limestone nodules exposed along the top of the road cutting from a point immediately below the garage as far as the entrance gate to the Cave Reserve. This horizon is approximately 600 feet above the top of the Cave Limestone.

The same bed is again encountered in the cutting on the east side of the road about 660 yards north of the bridge (Loc. B) where one particular bed is characterized by the same type of irregular nodules, some of which are crowded with specimens of *Gyroceratites desideratus*, but specimens of the same species also occur in mudstone just below the limestone nodule layer. Associated with it are specimens of *Lobobactrites inopinatus* and another indeterminate species of the same genus.

Locality C is situated further along the same road 220 yards east of the first sharp eastward bend, in the centre of a steep anticline formed by impure limestone, where *Lobobactrites inopinatus* and *Bactrites* sp. ind. were found in shales and mudstone

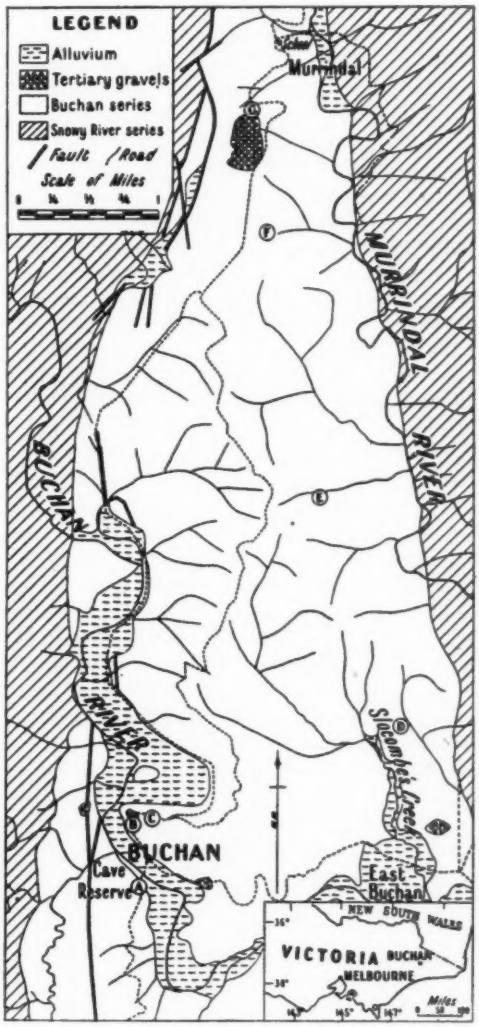


FIG. 1.—Geological sketch map of part of Buchan district. A–G localities at which goniatites were found.

bands between the limestone layers. The beds at this locality are about 250 feet lower in the sequence than those at Localities A and B.

Locality D, still lower stratigraphically, is situated in East Buchan, north of the East Buchan road, 2400 yards up Slocombe Creek from the road. Here *Bactrites howitti* was found in limestone nodules with *Chonetes australis*, at a level probably less than 300 feet above the top of the Cave Limestone of which there is a small outcrop in this creek. Locality E is at the same stratigraphical level, 1½ miles farther north.

Localities F and G are situated in the northern part of the sedimentary area in the coral reef facies of the Buchan series, stratigraphically 400 to 600 feet above the Cave Limestone. Locality F is situated 1.6 miles south of Murrindal and half a mile southeast of Sandy's Homestead on the Murrindal road. The goniatites occur here in coralliferous limestones, about 600 feet above the Cave Limestone, but unfortunately no specimens well enough preserved for generic identification were found. They belong, however, to the subfamily Anarcestinae of the family Anarcestidae.

The same type of goniatite is also found at Locality G in the big eastward bend of the road half a mile south of Murrindal school. These beds are probably only slightly higher in the sequence than those of Locality F. As in the previous locality they are associated with massive corals and *Receptaculites*.

Summarizing we may say that three distinct small goniatite faunas have been found in the Buchan district:

1. Fauna with *Bactrites howitti* (Loc. D and E).
2. Fauna with *Bactrites* sp. ind., *Lobobactrites inopinatus*, *Lobobactrites* sp. ind., and *Gyroceratites desideratus* (Loc. A, B, and C).
3. Fauna with Anarcestinae (Loc. F and G).

Fauna No. 1 is definitely the oldest, characterizing the mudstones with *Chonetes australis* immediately overlying the Cave Limestone. Although good specimens were only found at the localities indicated, traces of *Bactrites* were found in several other places at approximately the same stratigraphical level.

Faunas Nos. 2 and 3 are more or less contemporaneous, the *Gyroceratites-Lobobactrites* fauna characterizing the mudstone and impure limestone facies near Buchan, the Anarcestinae being restricted to the reef facies further north. All these goniatites occur between about 300 and 600 feet above the top of the Cave Limestone.

AGE OF THE FAUNA

The association of *Lobobactrites* and *Gyroceratites* indicates an early Middle Devonian age of the beds in which these genera occur. *Lobobactrites* is not found before the Middle Devonian and only one species is known from the early Upper Devonian (Schindewolf 1933, p. 73). *Lobobactrites clavus* (Hall), the only American representative of the genus, seems to range throughout the Middle Devonian (Miller, 1938, p. 41).

The relationships of *Gyroceratites* v. Meyer (= *Mimoceras* Hyatt) have been discussed in detail by Schindewolf (1933, p. 75). Only a few species are known, all of which occur in Germany and in Bohemia in the upper part of the Lower Devonian and the lower part of the Middle Devonian. *Bactrites* which, as indicated above, occurs in Buchan stratigraphically somewhat below the *Lobobactrites-Gyroceratites* fauna, has never been found below the Middle Devonian.

The indeterminate genus of the Anarcestinae, occurring at about the same level as the *Lobobactrites-Gyroceratites* beds indicates Middle or Upper Devonian. Of all the genera of the Anarcestinae only one, *Wernerоceras*, reaches up into the higher part of the Middle Devonian and even into the Upper Devonian. All other genera are restricted to the lower part of the Middle and the higher part of the Lower Devonian.

On the whole therefore the goniatites definitely indicate a lower Middle Devonian age for the beds immediately above the Cave Limestone. This correlation is also supported by the accompanying fauna which will be discussed elsewhere.

Middle Devonian goniatite faunas are generally neither very prolific nor widely distributed. They are best developed in Germany and it is from this country that the only other known associations of *Lobobactrites* and *Gyroceratites* with Anarcestinae

have been described, notably from the Wissenbach Schiefer of the Rhineland. The occurrence of a similar fauna in southeastern Australia is truly remarkable though hardly more so than the appearance of a succession of typical central European goniatite types in the Upper Devonian of northwestern Australia (Teichert 1943). Not until the Devonian goniatite faunas of central and southeastern Asia become better known will it be possible to establish definitely the routes by which these faunas invaded Australia from central Europe.

Reed (1908, p. 131) described indeterminate specimens of "*Anarcestes*" and "*Agoniatites*" from the Middle Devonian of Padaukpin in Burma. The specimen referred to the latter genus may possibly belong to *Gyroceratites*. I have previously (1943) called attention to certain affinities between the Padaukpin fauna and that of the Australian Middle Devonian.

DESCRIPTION OF SPECIES

Family BACTRITIDAE
Genus BACTRITES Sandberger
BACTRITES HOWITTI Teichert, n. sp.
Plate 16, figures 19–20

Conch medium-sized, orthoconic, slowly expanding orad, broadly elliptical in cross-section, slightly compressed laterally. Test probably very thin, external side not seen. Living chamber probably about as long as the phragmacone, but nature of aperture unknown. The surface of the internal mold of the living chamber shows very faint, indistinct elevations, sloping across the flanks probably from the antisiphonal to the siphonal side.

The most completely preserved fragment is a conch 31.5 mm. long, of which 13 mm. are occupied by a part of the phragmacone, consisting of six camerae. The dorso-ventral diameter of this specimen increases from 3.8 mm. at the adapical end to 7.0 mm. at the adoral end.

The septa are not very deeply concave. The sutures are almost at right angles to the longitudinal axis of the conch sloping at an angle of not more than 2° from the ventral towards the dorsal side. They are almost straight, although they form an extremely shallow and broad lateral lobe, and a shallow and narrow lobe on the ventral side which, however, only develops in maturity. A small specimen (pl. 16, fig. 18) with a dorso-ventral diameter of 3.5 mm. and a lateral diameter of 3.2 mm. has no ventral lobe. The suture across the ventral side is perfectly straight. The suture of another fragment, however (pl. 16, fig. 20), which has a dorso-ventral diameter of about 8 mm. and a lateral diameter of 7.0 mm., shows a very shallow ventral lobe rather shallower than that of typical *Bactrites schlotheimii* (see Schindewolf, 1933, pl. 4, fig. 7).

The siphuncle is narrow and situated close to though not in contact with the ventral wall of the conch. It seems that the septal funnels are rather long, reaching to within a short distance of the succeeding septal foramen.

Occurrence.—Localites D and E. Nos. 47644 (holotype), 47643, 47644, 47605, 47608, 47609, 47611, Mines Department, Melbourne.

The species has been named in honor of A. W. Howitt who pioneered the geology of Gippsland, Victoria, more than seventy years ago.

Remarks.—*B. howitti* is fairly large for a species of this genus. From most species of similar size it is distinguished by the nearly straight course of the sutures and the shallowness of the ventral lobe which is entirely absent in the early stages of the conch. *Bactrites* is not known to occur before the Middle Devonian. Other species occur in the upper Middle Devonian of northwestern Australia (Teichert 1943) but have not yet been described in detail.

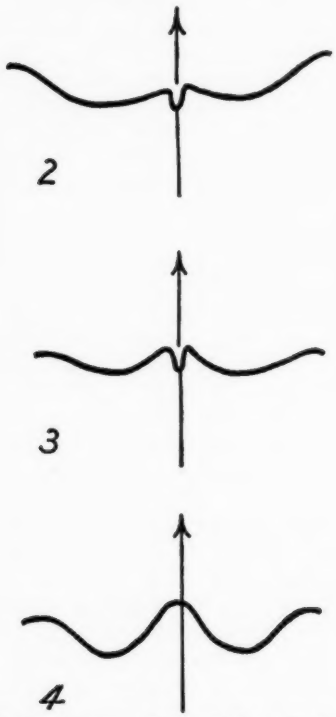
BACTRITES sp. ind.
Plate 16, figures 8–9

A fragment of a straight phragmacone, composed of only three camerae, does not belong to *Bactrites howitti*, but is too imperfectly preserved to be described specifically. The fragment is only 18 mm. long. The dorso-ventral diameter is about 15.5 mm., the lateral diameter 13.5, and the cross-section is evenly and broadly elliptical, with broadly rounded dorsal and ventral outlines. The distance between successive septa is about 5.5 mm.

The sutures are very slightly oblique sloping gently adapically from the dorsal side across the lateral sides towards the

venter. They have very shallow and broad lateral lobes and an almost imperceptible ventral lobe. The siphuncle is close to the ventral side.

Occurrence.—Locality C. Specimen No. 48088, Mines Department, Melbourne.



FIGS. *2–4.*—Sutures of Goniatites. 2, *Lobobactrites* sp.; 3, *Lobobactrites inopinatus* Teichert, n. sp.; 4, *Gyroceratites desideratus* Teichert, n. sp.

Genus LOBOBACTRITES Schindewolf

LOBOBACTRITES INOPINATUS

Teichert, n. sp.

Plate 16, figures 10–12, 16, 17

This species is represented by a few fragmentary phragmacones which have the compressed, elongated oval cross-section and the deeply sinuate sutures which are characteristic of the genus.

The specimen selected as the holotype is a fragment 20.5 mm. long which consists of six camerae. Its dorso-ventral diameter increases from 13.5 mm. at the adapical to 14.3 mm. at the adoral end. The lateral diameter increases from 9.0 to 9.6 mm. in the same distance. The cross-section is almost elliptical, with the ventral side only slightly more narrowly rounded than the dorsal side. The siphuncle is narrow and situated close to the more narrowly rounded, ventral side of the conch.

The camerae are 3.5 mm. high. The sutures (fig. 3) form high and narrow dorsal and ventral saddles and broad and rather deep lateral lobes. The ventral saddle is subdivided by a short acute ventral lobe, but this is not visible in the holotype. The ventral saddle being only very slightly higher than the dorsal one, the lateral lobe is rather symmetrical, with its deepest point in the middle of the flanks of the phragmacone.

One of the paratypes (48240) is a somewhat smaller fragment and may have belonged to the same conch of which the holotype forms a part. The specimens resemble the holotype in every respect and

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EXPLANATION OF PLATE 16

All specimens in the Geological Museum, Mines Department, Melbourne. All figures natural size, except 18–20, which are enlarged twice.

FIGS. *1–6—Gyroceratites desideratus* Teichert, n. sp. *1*, Paratype, No. 47983, Locality B, lateral view. *2–3*, Paratype, No. 47992, Loc. B, lateral and dorsal views. *4*, Holotype, No. 48749, Loc. A, lateral view. *5*, Specimen No. 48119, Loc. B, transverse section somewhat off center, showing slight unwinding of last whorl. *6*, Specimen No. 48144, Loc. B, longitudinal median section showing perforated umbilicus. (p. 65)

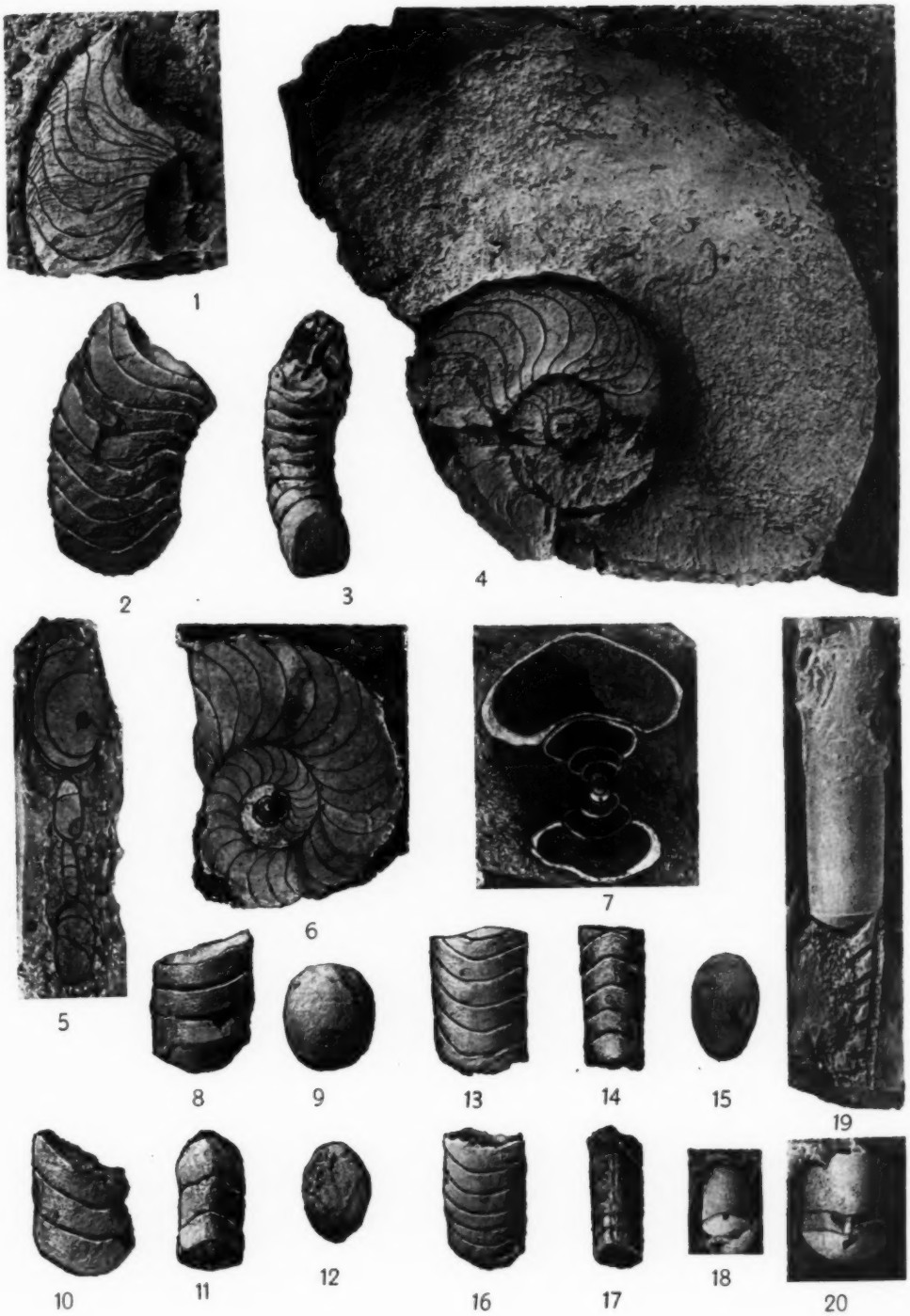
7—Anarcestes? sp. ind. No. 48467, Loc. F, transverse section. (p. 66)

8–9—Bactrites sp. No. 48088, Loc. C, lateral and adapical views. (p. 63)

10–12—Lobobactrites sp. ind. No. 48109, Loc. B, lateral, dorsal and adapical views. (p. 65)

13–17—Lobobactrites inopinatus Teichert, n. sp. *13–15*, Holotype No. 48239, Loc. C, lateral, dorsal, and adapical views. *16–17*, Paratype No. 48240, Loc. C, lateral and ventral views. (p. 64)

18–20—Bactrites hotvitti Teichert, n. sp. *18*, Paratype, No. 47643, Loc. D, ventral view. *19*, Holotype, No. 47644, Loc. D, lateral view. *20*, Paratype, No. 47605, Loc. D, ventral view.



Teichert, Devonian Goniatites from Victoria

the short acute ventral lobe of the suture is somewhat better seen. From these two specimens it may be estimated that a mature conch was probably not less than 20 cm. long.

A still smaller fragment (48680) represents the adapical portion of a small phragmacone and part of the living chamber. This specimen is 25.2 mm. long, 9.5 mm. of which are occupied by the phragmacone of which 4 camerae are preserved. The dorso-ventral diameter of the conch increases from 10.7 to 12 mm., the lateral diameter from 7 to about 8 mm. The shape of the cross-section of the conch as well as the course of the sutures are similar to conditions in the holotype.

Occurrence.—Locality B (Nos. 48112, 48680, Mines Department, Melbourne) where it is associated with *Bactrites* sp. ind., *Lobobactrites* sp. and *Gyroceratites desideratus*, Locality C (Nos. 48239, 48240, Mines Department, Melbourne) where it is associated with *Lobobactrites* sp. only.

Remarks.—From the genotype, *L. ellipticus* (Frech) this species is distinguished by its greater size, from the American *L. clavus* (Hall) by its more densely spaced septa and the more strongly compressed cross-section of its conch. *L. timanicus* Schindewolf (= *Bactrites subflexuosus* Keyserl., *vide* Holzapfel, 1899, pl. 10, figs. 1–3, 9b) has asymmetrical lateral lobes and *L. gürichi* (Rhezak) (= *Bactrites carinatus* Gürich, 1896, pl. 13, figs. 7a–e) is a much smaller species with a distinct ventral keel.

LOBOBACTRITES sp. ind.
Plate 16, figures 13–15

Several fragmentary specimens which clearly belong to the genus *Lobobactrites* are definitely distinct from the species described above. Although undoubtedly they belong to a new species, they are too imperfectly preserved to be described specifically.

The main points of difference by which this species may be distinguished from *L. inopinatus* are probably the following:

(1) The cross-section of the conch is still more strongly compressed, with both the dorsal and ventral sides very narrowly rounded. The ventral side may even possess an indistinct keel.

(2) The distance between the septa is greater, probably by about 50 per cent.

(3) The lateral lobes of the sutures are strongly asymmetrical, the dorsal saddle rising considerably higher than the ventral one. Consequently the deepest point of the lateral lobe is much nearer the ventral than the dorsal side (fig. 2).

Even in imperfectly preserved specimens this species should always be easily distinguishable from *L. inopinatus*. Its formal description must however be postponed until better material is available.

Occurrence.—Locality B (Nos. 48019, 48685) and Locality C (Nos. 48242, 48245–48247).

Family GYROCERATITIDAE
GYROCERATITES von Meyer
GYROCERATITES DESIDERATUS
Teichert, n. sp.
Plate 16, figures 1–6

Conch large, discoidal; whorls strongly compressed with narrowly rounded ventral and dorsal sides and flattened flanks which are only slightly converging ventrad. Mature specimens must have attained a diameter of at least 100 mm. The whorls are in contact with each other, but there is no impressed zone along the dorsal side. It seems that in some specimens at least the last whorl becomes somewhat uncoiled, but the distance of its dorsal side from the ventral side of the last preceding whorl remains small, of the order of about 1 mm. or so.

No specimens with a perfectly preserved umbilical part are known, though from available evidence it seems that the umbilicus is probably perforate (pl. 16, fig. 6).

The surface of the shell is covered with densely spaced fine and sharp ribs which are somewhat sickle-shaped. They are strongly bent back along the ventral side, are slightly sinuous along the flanks, but their course near the umbilical shoulder and across the dorsal side cannot be very accurately seen in the only specimen in which traces of the surface ornamentation are preserved. In typical *Gyroceratites* they should cross the dorsal side in a low saddle and it is indeed probable they do so in the present species.

The sutures (fig. 4) are simple and more or less identical with those of other species of the genus. They cross the flanks of the

shell in a deep and broad lobe, forming low dorsal saddles, high and narrow ventro-lateral saddles, and narrow and short ventral lobes.

This species is known from a number of more or less fragmentary, mostly poorly preserved specimens. The holotype (No. 48749, pl. 16, fig. 4) is a large specimen, consisting of more than two and a half volutions, with the incompletely preserved living chamber occupying three-quarters of the last whorl. The greatest diameter of the conch is 98 mm. The umbilicus is not well preserved, though it seems as if it is rather widely perforate. The dorso-ventral diameter of the whorls increases from 3 mm. near the apical end to about 35 mm. at the oral end; since the aperture is not preserved it is impossible to tell the original size of the specimen. The whorls are in contact along their entire length, but there is of course no impressed dorsal zone. The sutures are well shown, but not the surface ornamentation. The latter is well seen in paratype No. 47983 (pl. 16, fig. 1), which also shows well the shape of the whorls and the sutures.

Some internal casts (pl. 16, figs. 1, 2) show indications of somewhat stronger ribbing. These ribs are more widely spaced than the fine ribs on the surface of the shell and they seem to form one broad lateral saddle. They are probably impressions of faint furrows on the inner side of the shell.

A slight tendency towards uncoiling was seen in one specimen only (No. 48119, pl. 16, fig. 5). In a cross-section measuring 53 mm. the dorsal side of the last whorl is about 1 mm. distant from the ventral side of the preceding whorl. The whorls of this specimen also show faint traces of an impressed zone along the dorsal side which however is not more than the merest fraction of a millimeter deep.

Another paratype (No. 48144, pl. 16, fig. 6) shows an almost median longitudinal section which also suggests a perforated umbilicus with an opening about 3 mm. wide. This specimen has a maximum diameter of 40 mm. and consists of about two and one-quarter whorls which increase in height from about 2 to 16.5 mm. At the adoral end of the specimen the septal necks are well shown in the section. They are directed backward, straight, and about 1.5 mm. long.

Occurrence.—Locality A, Nos. 48749–48751. Localities B, Nos. 47983–47986, 47991–47994, 48009, 48012, 48028–48031, 48111, 48116–48120, 48130–48132, 48137, 48138, 48140–48145.

Remarks.—As may be expected in a primitive, as yet little specialized genus there are but few features by which species may be distinguished. *Gyroceratites desideratus* agrees perfectly well with the generalized description of the genus given by Schindewolf (1933, p. 74) and its suture is indistinguishable from that of the genotype, *G. gracilis* Bronn (Schindewolf, 1933, p. 52). The Australiam species is, however, considerably larger than other known species of the genus. One of the larger known European species, *G. ambigena* (Barrande, 1865), is only about half the size of *G. desideratus*. Its size must, therefore, be regarded as the most important specific feature of *G. desideratus*. Some specimens of *Goniatites fecundus* Barrande obviously belong to *Gyroceratites*, for example the one figured in 1865, pl. 10, figs. 8–10. Barrande (1867, p. 32) says that in this species there is no dorsal impression in the whorls, but some of his specimens (pl. 7, figs 10–11) have such an impression and should probably be transferred to *Mimagoniatites* or *Agoniatites*. *Gyroceratites fecundus* is the only species of the genus which approaches *G. desideratus* in size.

Family Anarcestidae
Subfamily Anarcestinae
Anarcestes ? sp. ind.
Plate 16, fig. 7

This species can only be inadequately described from cross-sections in hard limestone from which it has been impossible to free any complete specimens.

The shell is subglobular and has a wide and deep umbilicus. As far as the fragmentary material allows one to judge the umbilicus is imperforate. The whorls increase rapidly in lateral diameter, their cross-section being reniform, though not very strongly arcuate.

The largest specimen seen has about five whorls and its diameter is over 40 mm. At its adapical end the lateral diameter of the conch is 36 mm. and the height of the whorl about 19 mm.; the distance between the ventral side of the whorl and the impressed

dorsal zone is here 16 mm. Thus, the depth of the impressed zone is only about one-sixth of the height of the whorl.

The ventral side of the whorls is broadly and evenly rounded. Ventro-laterally the conch is sharply rounded and the umbilical flank is almost flat in the mature stage, slightly convex in earlier stages of growth.

Occurrence.—Localities F and G. Nos. 48145, 48423, 48424, 48426, 48427, 48432, 48467, 48484, 48498.

Remarks.—Among Middle Devonian goniatites this form resembles members of the family Anarcestidae which has been revised by Schindewolf in 1933. It would appear that on account of the subglobular shape of its conch the Buchan species belongs to the subfamily Anarcestinae rather than to the more discoidal Pinacitinae.

Since it is impossible to decide with certainty whether or not the umbilicus in the Australian specimen is perforate or imperforate and in the absence of any information on the suture, the generic position of these fossils must remain doubtful. Almost all Anarcestinae have whorls with more strongly bent cross-sections and consequently a more deeply concave dorsal side. *Anarcestes karpinskyi* Holzapfel (1895, pl. 3, fig. 15) resembles the Australian form in cross-section. According to Schindewolf (1933, p. 94) this species must now be referred to *A. rouvillei* von Koenen and belongs to *Werneroceras*, a genus restricted to the Middle and early Upper Devonian.

MANUSCRIPT RECEIVED APRIL 14, 1947.

REFERENCES

BARRANDE, J., 1865, Système Silurien du Centre de la Bohême. I, Recherches paléontologiques; 2, plates 1–107.

——, 1867, Système Silurien, etc. I. Recherches paléontologiques, 2, Texte, part 1. XXXVI and 712 pp.

GÜRICH, G., 1896, Das Palaeozoikum im Polnischen Mittelgebirge: Verh. Kais.-Russ. Min. Ges. (2), vol. 32. 539 pp.

HOLZAPFEL, E., 1895, Das Obere Mitteldevon im Rheinischen Gebirge: Abh. Preuss. Geol. Landesanst., N.F., heft 16. 459 pp. 19 pls.

——, 1899, Die Cephalopoden des Domanik im südlichen Timan: Mém. Com. géol., vol. 12, no. 3, 56 pp.

KINDLE, E. M., and MILLER, A. K., 1939, Bibliographic index of North American Devonian Cephalopoda: Geol. Soc. America, Spec. Pap. no. 23, 179 pp.

MILLER, A. K., 1938, Devonian Ammonoids of North America: Geol. Soc. America, Spec. Pap. no. 14, 262 pp., 39 pls.

REED, F. R. C., 1908, The Devonian faunas of the Northern Shan States: Pal. India, n.s., vol. II, mem. no. 5, 183 pp., 20 pls.

SCHINDEWOLF, O. H., 1933, Vergleichende Morphologie und Phylogenie der Anfangskammern tetrabranchiater Cephalopoden: Abh. Preuss. Geol. Landesanst., N.F., heft 148, 115 pp., 4 pls.

TEICHERT, C., 1941, Upper Devonian Goniatite succession of Western Australia: Amer. Jour. Science., vol. 239, pp. 148–153.

——, 1943, The Devonian of Western Australia: Ibid., vol. 241, pp. 69–94, 167–184.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 68–74, PL. 17, JANUARY 1948

A REVISION OF SOME MISSISSIPPIAN TETRACORAL GENERA

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ABSTRACT—The Mississippian tetracoral genera *Cystelasma*, *Bordenia*, *Trochophyllum*, and *Enallophyllum* are redescribed and figured. The relationships between *Cystelasma* and other genera with pseudopentameral symmetry are discussed. The genus *Crassiphyllum* is reduced to synonomy with *Trochophyllum*, and *Enallophyllum* is proved to be congeneric with *Hapsiphyllum*.

INTRODUCTION

A NUMBER of small Mississippian tetracoral genera from the New Providence shale of Kentucky and the Salem limestone of southern Indiana and northern Kentucky have been imperfectly understood because of the lack of knowledge of their internal structures. The aim of this paper is to present emended descriptions of these genera based on their internal as well as their external structures, and to reduce to synonomy certain duplications in generic and specific names.

I wish to thank Dr. G. A. Cooper of the U. S. National Museum for the loan of hypotypes of *Cystelasma lanesvillense*, *C. tabulatum*, *C. rugosum*, *C. quinqueseptatum*, *Bordenia zaphrentiformis*, and *Trochophyllum verneuili*, and to thank Dr. Otto Haas of the American Museum of Natural History for the loan of the syntypes of *Enallophyllum grabaui*.

DESCRIPTION OF GENERA AND SPECIES

Genus CYSTELASMA Miller 1891

Cystelasma MILLER, 1891 (15), p. 12; 1892 (16), p. 623.
Cystelasma BEEDE, 1906 (1), p. 1207.

Genotype.—By original designation, *Cystelasma lanesvillense* Miller, 1891, p. 12, pl. 1, figs. 15–16; 1892, pl. 1, figs. 15–16.

Occurrence.—Middle Mississippian, Salem limestone: Lanesville, Indiana.

Generic description.—Small, simple, irregularly subcylindrical corals possessing a very heavy, concentrically wrinkled epitheca that is usually extended along one side to produce one or more talons. The calyxes are funnel-shaped with erect or gradually expanding walls, the walls often appearing multiple because of elongate, vertically disposed peripheral dissepiments that extend above the base of the calyx and may reach as high as the margins. The cardinal, alar, and counter-lateral septa are always present, usually producing a pseudopentameral symmetry. Metasepta may be present or absent, and minor septa are absent. The septa may extend from the periphery or from one of the inner walls produced by the elongate dissepiments, or may be discontinuous septal crests across the peripheral portions of the calyxes. Tabulae are typically complete, horizontal, and spaced from 0.5 to 2 mm. apart. Occasional ones may be incomplete, or distally concave, or both. Peripheral dissepiments are usually present, often only along one side of the corallum. They may be steeply inclined or vertical, and their distal ends may project into the calyx.

Remarks.—The unusual septal development characteristic of *Cystelasma* is present in several other genera of Devonian, Carboniferous, and Permian age. The only Devonian genus displaying it is *Oligophyllum* Počta in Barrande, 1902 (17), pl. 6, pp. 7–9; text figs. 8–9, on p. 192. In the genotype species *O. quinqueseptatum* the five protosepta appear exactly as in *Cystelasma* and the metasepta appear as short peripheral ridges in later growth stages. The genus differs from *Cystelasma* in the apparent lack of horizontal skeletal elements.

The Lower Carboniferous genus *Cryptophyllum* Carruthers, 1919 (3), p. 439 with

genotype *C. hibernicum* from the Lower Carboniferous limestone of Ireland also shows the identical septal development, but here in advanced growth stages the metasepta approach the length of the five protosepta and the pseudopentameral symmetry becomes obscure. *Cryptophyllum* differs from *Cystelasma* also in that minor septa appear in later growth stages and the tabulae are few and irregular. The septal structure of *Cystelasma lanesvillense* is far more weakly developed than that of the species of *Oligophyllum* and *Cryptophyllum*, but the tabulae are much more highly developed. It is possible that *Cryptophyllum* is congeneric with *Pentaphyllum* de Koninck, 1872 (14), p. 321 (preoccupied) with genotype *P. armatum* from the Lower Carboniferous of Belgium.

In the Permian the genus *Plerophyllum* Hinde, 1890 (13), p. 195, with genotype *P. australe* from the Permian of western Australia shows the same septal development with the five protosepta developing rhopaloid axial ends and the metasepta becoming almost as long in mature growth stages. Hinde does not mention whether tabulae or dissepiments are present. The genera *Tachylasma* Grabau, 1922 (7), p. 34 with genotype *T. cha* from the Permian of Yunnan, and *Ufimia* Stuckenberg, 1895 (20) p. 184 with genotype *U. carbonaria* from the Upper Carboniferous of the Ural mountains differ from the genera previously discussed in that the cardinal septum is aborted and the alar and counter-lateral septa, usually with rhopaloid axial ends, form the protosepta. In the later growth stages of these genera metasepta become almost as long as the protosepta and minor septa appear. Grabau mentions a sparse development of dissepiments in *Tachylasma cha* but does not state whether tabulae are present or absent. *Ufimia* and *Tachylasma* may be congeneric.

The interesting genus *Hexalasma* Soshkina, 1928 (19), p. 366 (preoccupied) with genotype *H. primitivum* from the Permian of the Ural Mountains differs in that the counter septum also becomes long at an early growth stage and together with the counter-lateral, alar, and cardinal septa produces a pseudohexameral symmetry. This genus differs from all those previously discussed in that the septa degenerate and become vestigial with maturity.

CYSTELASMA LANESVILLENSE Miller, 1891
Plate 17, figures 1–4

Cystelasma lanesvillense MILLER, 1891 (15), p. 12, pl. 1, figs. 15–16.
Cystelasma lanesvillense MILLER, 1892 (16), p. 623, pl. 1, figs. 15–16.
Cystelasma lanesvillense BEEDE, 1906 (1), p. 1208, pl. 8, figs. 3–3d.

Description.—Small, simple, irregularly subcylindrical to ceratoid corals varying from 10 to 20 mm. in length with a maximum diameter of 8 mm. across the calyx margins. The epitheca is very thick and wrinkled, and is usually projected outward along one side near the base to produce a series of small talons. The calyx is funnel-shaped, varying from 3 to 7 mm. in depth, and has vertical or gradually expanding walls. It is often divided into compartments by the distal edges of elongate dissepiments. Faint septal striae may be present or absent on the inner side of the calyx walls. In the transverse section the cardinal, alar, and counter-lateral septa appear as short ridges extending less than 1 mm. from the periphery. No other septa are visible in the section. In the longitudinal section occasional elongate, vertically disposed peripheral dissepiments are present. These may run parallel to the peripheral wall all the way to, and sometimes through the calyx, or may abut against the wall at the distal as well as at the proximal end. These dissepiments are intermittently developed and are often present only along one side of the corallum. Tabulae are prominent, usually complete and horizontally disposed, varying from .5 to 2 mm. apart.

Occurrence.—Middle Mississippian, Salem limestone: Lanesville, Indiana.

Hypotypes.—U. S. Nat. Museum collection.

CYSTELASMA TABULATUM Beede, 1906
Plate 17, figures 8–10

Cystelasma tabulatum BEEDE, 1906 (1), p. 1219, pl. 8, figs. 1–1c.

Description.—Small, simple, subcylindrical to ceratoid rugose corals with external form very similar to *C. lanesvillense* with the exception that the five protosepta are more highly developed, extending almost to the axis at the base of the calyx and that the elongate dissepiments are absent so that the

calyx is not divided into compartments. In some specimens faint peripheral striae on the inner side of the calyx walls between the protosepta indicate the position of metasepta. In a transverse section cut about halfway between the proximal and distal ends of a specimen the cardinal, alar, and counter-lateral septa are quite prominent, extending from the peripheral wall about one-half the distance to the axis. No other septa are visible. The longitudinal section shows complete, horizontal, rather widely spaced tabulae. No peripheral dissepiments are present.

Occurrence.—Middle Mississippian, Salem limestone: Spergen Hill, Washington County, Indiana.

Hypotypes.—U. S. Nat. Museum collection.

CYSTELASMA SEPTATUM Greene, 1901
Plate 17, figures 11–12

Cystelasma septatum GREENE, 1901 (9), p. 56, pl. 19, figs. 10–19.
Cystelasma septatum BEEDE, 1906 (1), p. 1209, pl. 8, figs. 2–2d.
Cystelasma rugosum BEEDE, 1906 (not Ulrich, 1905), ibid., p. 1210, pl. 7, figs. 5–5b.

Description.—Small, simple rugose corals with external form similar to *C. lanesvillense* and *C. tabulatum* with the exception that the elongate, vertically disposed dissepiments are very highly developed so that the peripheral portions of the calyxes have the appearance of lonsdaleioid dissepimentaria, and that in addition to long protosepta the metasepta are well developed. In the calyxes the cardinal, alar, and counter-lateral septa extend almost to the axes, but tend to break up peripherally into discontinuous septal crests as they cross the peripheral dissepimentaria. In some specimens the protosepta have rhopaloid axial ends. The metasepta are usually short, often appearing as discontinuous crests across the dissepimentaria, but an occasional one may become as long as a neighboring protoseptum. The tabulae are similar to those of *C. lanesvillense*, but are more closely set. Elongate, vertically disposed peripheral dissepiments are more highly developed than in any other species of *Cystelasma*.

Occurrence.—Middle Mississippian, Salem limestone: Spergen Hill, Washington County, Indiana.

Hypotypes.—U. S. Nat. Museum collection.

CYSTELASMA RUGOSUM Ulrich, 1905
Plate 17, figures 16–20

Cystelasma rugosum ULRICH, 1905 (21), p. 46, pl. 5, figs. 12a–g.
not *Cystelasma rugosum* BEEDE, 1906 (1), p. 1210, pl. 7, figs. 5–5b which is *C. septatum* Greene.
Cystelasma rugosum ULRICH, 1917 (22), pl. 14, fig. 13.

Description.—The corallum is usually very short and irregularly subcylindrical and possesses an unusually heavy, transversely wrinkled epitheca that is projected along one side into a multiple series of irregular talons. The calyx is conical with gradually expanding walls and erect margins. Average specimens are 10 mm. long and about 5 mm. in diameter across the calyxes. The five protosepta extend from the periphery over half the distance to the axis. Metasepta appear as peripheral striae along the inner side of the calyx walls. Dissepiments rarely extend into the calyx, but a single series of them may do so giving a double-walled appearance to the calyx margins of occasional specimens. The transverse section is very similar to that of *C. septatum* but the longitudinal section differs in that the peripheral dissepimentarium is not as well developed and the dissepiments with few exceptions abut against the peripheral wall at their distal ends and do not enter the calyx. The tabulae are horizontal and widely spaced.

Occurrence.—Middle Mississippian, Ste. Genevieve limestone, Fredonia oolite member: Princeton, Kentucky.

Hypotypes.—U. S. Nat. Museum collection.

CYSTELASMA QUINQUESEPTATUM Ulrich 1905
Plate 17, figures 5–7

Cystelasma quinqueseptatum ULRICH, 1905 (21), p. 46, pl. 5, figs. 13a–p.
Cystelasma quinqueseptatum ULRICH, 1917 (22), pl. 14, fig. 14.

Description.—Long, very slender subcylindrical corals, often reproducing by lateral budding so that they may be found in groups of two or three attached individuals. Average length of coralla 20 mm. with a maximum calyx diameter of 3–4 mm. Epitheca heavy, not as coarsely annulated as in *C. rugosum*, often projected into a

series of small, spinose talons along one side near the base. Calyx very deep with erect walls. The five protosepta are well developed, extending about two-thirds the distance to the axis. The metasepta indicated by from one to three peripheral striae between the protosepta. In the longitudinal section the tabulae are horizontal, complete, and spaced from 0.5 to 2 mm. apart. No dissepiments are present.

Occurrence.—Middle Mississippian, Ste. Genevieve limestone, Fredonia oolite member: 2 miles east of Princeton, Kentucky.

Hypotypes.—U. S. Nat. Museum collection.

Genus TROCHOPHYLLUM Edwards and Haime 1850

Trochophyllum, EDWARDS and HAIME, 1850 (5), p. lxvii.
Trochophyllum, EDWARDS and HAIME, 1851 (6), pp. 166, 356.
Crassiphyllum GROVE, 1935 (10), p. 368.

Genotype.—By original designation, *Trochophyllum verneuili* Edwards and Haime, 1850, p. lxvii; 1851, p. 166; described and name unwarrantedly changed to *Trochophyllum verneuilanum* on p. 357. Lower Mississippian, New Providence shale: 7 miles S. of Louisville, Kentucky.

Generic description.—Small, simple, ceratoid to trochoid rugose corals with a thin epitheca through which the thick peripheral edges of the septa are visible and often elevated to form pseudocostae. Calyxes shallow with rapidly expanding walls. Septa of equal size and typically wedge-shaped, thick at the periphery and attenuating axially. In some specimens the cardinal septum is slightly shorter than the others. No minor septa are present. By the addition of stereoplasm to the axial ends of the septa a stereocolumella is produced. This structure is normally open in the center leaving a vertical hollow axial tube, but in some specimens it is filled in with stereoplasm at the base of the calyx. Tabulae are very thin, horizontal, and widely spaced. There are no dissepiments.

TROCHOPHYLLUM VERNEUILI Edwards and Haime 1851. Plate 17, figures 25–29

Trochophyllum verneuili EDWARDS and HAIME, 1850 (5), p. lxvii (species mentioned by name only).
Trochophyllum verneuili EDWARDS and HAIME, 1851 (6), (species mentioned by name only on p. 166, described as *Trochophyllum verneuilanum* on p. 357).
Zaphrentis declinis MILLER, 1891 (13), p. 12, pl. 1, figs. 25–26.
Crassiphyllum declinis GROVE, 1935 (10), p. 369, pl. 9, figs. 9–11; pl. 12, figs. 12–16.

Description.—Small, typically curved ceratoid or trochoid rugose corals varying from 15 to 20 mm. in length and from 6 to 8 mm. in diameter at the calyx. The epitheca is very thin and the peripheral edges of the septa make distinct longitudinal ridges on the exterior. The calyx is shallow with rapidly spreading walls. Septa of one order, varying from 18 to 24 in number in different individuals. They are thick peripherally and taper down to thin axial ends near the axis of the corallum. The cardinal septum is on the convex side of the corallum and in some specimens is slightly shorter than the others without producing a fossula. In other specimens it is indistinguishable by size from the others. The axial ends of the septa are reenforced and the interspaces filled with stereoplasm to form a small flat space at the center of the calyx. In some specimens this space is open at the center to produce the aperture of a small axial tube, in others this is sealed over by the stereoplasm. This axial region is never elevated to produce a columella. In transverse section the septa are seen to be radially arranged and the stereoplasmic filling of the axial interspaces, leaving a small axial tube, is prominent. In longitudinal section a few small, very thin tabulae may be seen extending from the peripheral walls. They become lost in the axial stereoplasmic zone. There are no dissepiments.

Occurrence.—Lower Mississippian, New Providence shale: Buttonmould Knob, Bullitt County, Kentucky.

Hypotypes.—U. S. Nat. Museum collection.

Genus BORDENIA Greene 1901

Bordenia GREENE, 1901 (9), p. 57.
Bordenia BEEDE, 1906 (1), p. 1205.

Genotype.—By original designation, *Bordenia zaphrentiformis* Greene, 1901, p. 57, pl. 19, figs. 2–9. Middle Mississippian,

Salem limestone: Harrison, Floyd, and Washington Counties, Indiana.

Generic description.—Simple, irregularly ceratoid or trochoid corals having a very heavy epitheca projected along one side to produce a thickened, elongate talon often extending from the base two-thirds of the way to the calyx margin. In some specimens the upper portion of the epitheca is thinner so that interseptal striae become visible. The calyx is shallow with broadly expanding walls. The septa are of two orders, major and minor. The former extend over the distal surface of each tabulum almost to the axis but retreat almost to the periphery in the intertabulate areas. The alternate minor septa follow the same pattern but never attain the length of the major. There is no characteristic modification of the protosepta. Tabulae are complete, horizontal, and widely spaced. There are no dissepiments.

BORDENIA ZAPHRENTIFORMIS
Greene 1901
Plate 17, figures 13–15

Bordenia zaphrentiformis GREENE, 1901 (9), p. 57, pl. 19, figs. 2–9.
Bordenia zaphrentiformis BEEDE, 1906 (1), p. 1205, pl. 7, figs. 6–6c.

Description.—Trochoid rugose corals with a heavy, coarsely annulated epitheca that is thickened and projected along one side to produce a massive, elongate talon. The calyx is very shallow with low, spreading walls. As seen in the calyx the septa are of two orders of which the major extend from one-half to two-thirds the distance to the axis, leaving a smooth tabulate floor in the axial region. In some specimens the cardinal septum is slightly shorter but no characteristic fossula is produced. The alternate minor septa extend down the inner side of the calyx wall as short striae but do not extend any appreciable distance outward on the calyx floor. The number of septa varies from 30 to 36 in different specimens. Specimens broken longitudinally show the unusual septal development in the intertabulate areas. The tabulae are smooth, horizontal, and spaced an average distance of 2 mm. apart. On the distal surface of each tabulum the major septa extend from one-half to two-thirds the distance to the axis and the minor septa extend outward a short distance. In the intertabulate areas both series of septa retreat almost to the periphery only to spread axially again on the distal surface of the next overlying tabulum.

EXPLANATION OF PLATE 17

FIGS. *1–4—Cystelasma lanesvillense* Miller. *1*, side view of hypotype ×1½; *2*, calyx of another hypotype ×1½; *3*, transverse section cut ¼ inch below calyx, counter-lateral septa at base, ×1½; *4*, longitudinal section ×1½. (p. 69)

5–7—Cystelasma quinqueseptatum Ulrich. *5*, side view of a hypotype ×1½; *6*, calyx view, counter-lateral septa at base, ×1½; *7*, longitudinal section ×1½. (p. 70)

8–10—Cystelasma tabulatum Beede. *8*, calyx of hypotype ×1½ showing long protosepta; *9*, transverse section cut midway between base and calyx ×1½; *10*, longitudinal section ×1½. (p. 69)

11–12—Cystelasma septatum Greene: *11*, calyx of hypotype showing protosepta, metasepta, and vertical peripheral dissepiments ×1½; *12*, side view of decorticated specimen showing protoseptum, tabulae, and elongate peripheral dissepiments ×1½. (p. 70)

13–15—Bordenia zaphrentiformis Greene. *13*, calyx of hypotype ×1½; *14*, side view of broken specimen showing complete tabulae and amplexoid septa ×1½; *15*, side view of another hypotype showing heavy epitheca and massive talon. (p. 72)

16–20—Cystelasma rugosum Ulrich. *16*, calyx of hypotype showing protosepta and peripheral metasepta ×1½; *17*, calyx of another individual in which metasepta are feebly developed ×1½; *18*, transverse section cut just below calyx showing long protosepta ×1½; *19*, longitudinal section in which the tabulae and well developed peripheral dissepiments are seen ×1½; *20*, side view of another hypotype showing heavy, wrinkled epitheca and talon. ×1½ (p. 70)

21–24—Hapsiphyllum grabaui (Greene). *21*, calyx of lectotype ×2; *22*, calyx of another syntype (original of Greene's fig. 18) ×2; *23*, side view of lectotype showing short spines near base ×2; *24*, side view of broken specimen (original of Greene's fig. 16) ×2. (p. 73)

25–29—Trochophyllum verneuili Edwards and Haime. *25*, transverse section cut midway between base and calyx ×1½; *26*, side view of hypotype ×1½; *27*, calyx of another hypotype showing shortened cardinal septum at top ×1½; *28*, view of convex side of corallum showing pinnate development of metasepta along the cardinal septum ×1½; *29*, longitudinal section ×1½. (p. 71)

Stumm, Mississippian Tetracoral Genera

Remarks.—Septa with the arrangement characteristic of this species were termed amplexoid septa by Carruthers, 1910 (2), p. 525, as the same structure is present in *Amplexus coralloides* the genotype of *Amplexus*. The majority of authors use the term for short septa in general rather than for this specific type of septal development. In referring to the septa of *Bordenia zaphrentiformis* as amplexoid septa *sens. str.* it is evident that *Bordenia* and *Amplexus* are closely related and that *Bordenia* differs only in its trochoid form, heavy epitheca with talon, and the greater axial extent of the major septa over the distal surfaces of the tabulae.

Occurrence.—Middle Mississippian, Salem limestone: 2 miles south of Colesburg, Kentucky.

Hypotypes.—U. S. Nat. Museum collection.

Genus HAPSIPHYLLUM Simpson 1900

Hapsiphyllum SIMPSON, 1900 (18), p. 203.
Enallophyllum GREENE, 1901 (9), p. 54.

Genotype.—By original designation, *Zaphrentis calcariformis* Hall, 1882 (11), p. 33; 1883 (12), p. 293, pl. 21, figs. 10–11 = *Zaphrentis cassedayi* Edwards, 1860 (4), p. 341, pl. Gl, figs. 2, 2a–b. Middle Mississippian, Salem limestone: Spergen Hill and other localities in southern Indiana. Hall's designated horizon and locality of Corniferous limestone: Falls of the Ohio, is in error.

HAPSIPHYLLUM GRABAUI (Greene) 1901
Plate 17, figures 21–24

Enallophyllum grabaui GREENE, 1901 (9), p. 54, pl. 20, figs. 8–18.
Enallophyllum grabaui BEEDE, 1906 (1), p. 1206, pl. 7, figs. 2, 2a–d.

Description.—Simple, irregularly curved ceratoid corals with an epitheca provided with irregularly spaced, short spines, that are more numerous near the base of the corallum. Calyx with a flat base and vertical walls taking up as much as one-third the length of the corallum. Dimensions of corallum of average size are: 15 mm. long, and 7 mm. in diameter at the calyx. The cardinal septum is short and normally on the concave side of the corallum, but irregular twisting during growth of the corallum may cause it to appear lateral, or rarely on the convex side. The cardinal-lateral septa are very long and by fusing with the axial ends of the other major septa produce a fossula in the form of a solid inner wall that is swollen in the axial region and becomes attenuate toward the cardinal septum. It fuses with the outer wall on either side of the cardinal septum. The major average 20 in number and between each, with the exception of posititions on either side of the cardinal septum, is a minor septum varying from one third to one-half as long. The axial end of each minor septum is attached to the neighboring major septum. Weathered specimens showing the horizontal skeletal elements show the presence of evenly spaced, horizontal tabulae within the incomplete phyllotheca produced by the axial ends of the major septa. There are no dissepiments in the peripheral area.

Remarks.—The structure of *Hapsiphyllum grabaui* is almost identical with that of *H. cassedayi* with the exception that the former is about one-half the size and possesses about 20 fewer septa than the latter. It may well be that the syntypes of *H. grabaui* are immature specimens of *H. cassedayi*.

Occurrence.—Middle Mississippian, Salem limestone: Lanesville, Indiana:

Syntypes.—Amer. Mus. Nat. Hist. 23623–23633, inclusive. Lectotype, the original of Greene's fig. 14 is no 23629.

REFERENCES

(1) BEEDE, J. W., 1906, in Cumings and Beede, Fauna of the Salem limestone of Indiana: Indiana Dept. Geology, Ann. Rept. no. 30.
(2) CARRUTHERS, R. G., 1910, On the evolution of *Zaphrentis delanouei* in Lower Carboniferous times: Geol. Soc. London Quart. Jour. vol. 66.
(3) ——, 1919, A remarkable Carboniferous coral: Geol. Mag., n.s., vol. 6, no. 10.
(4) EDWARDS, H. M., 1860, Hist. Nat. Corr., vol. 3.
(5) ——, and HAIME, J., 1850, British fossil Corals, pt. 1, Introd.
(6) ——, 1851, Mon. Polyp. foss. Terr. Palaeoz.
(7) GRABAU, A. W., 1922, Palaeozoic corals of China (1): Pal. Sinica, ser. B, vol. 2, no. 1.
(8) ——, 1928, Paleozoic corals of China (2): Ibid., vol. 2, no. 2.
(9) GREENE, G. K., 1901, Contr. Indiana Paleont., vol. 1, no. 7.
(10) GROVE, B. H., 1935, Studies in Paleozoic corals: Amer. Midland Nat., vol. 16, no. 3.

(11) HALL, J., 1882, Descriptions of fossil corals from the Niagara and Upper Helderberg groups: Adv. sheets, N. Y. State Mus., Ann. Rept. no. 35.
(12) ——, 1883, Descriptions of fossil corals from the Niagara and Upper Helderberg groups of Indiana: Indiana Dept. Geol. Nat. Hist., Ann. Rept. no. 12.
(13) HINDE, G. J., 1890, Notes on the Palaeontology of Western Australia: Geol. Mag., ser. 3, vol. 7.
(14) KONINCK, L. G. de, 1872, Nouv. Rech. Anim. Foss. Terr. Carb. Belgique.
(15) MILLER, S. A., 1891, Paleontology: Adv. sheets, Geol. Surv. Indiana, 17th Rept.
(16) ——, 1892, Geol. Survey Indiana, 17th Rept.
(17) POČTA, P., 1902, in Barrande, J., Syst. Sil. Centre Boheme, vol. 8, pt. 2.
(18) SIMPSON, G. B., 1900, Preliminary descriptions of new genera of Paleozoic rugose corals: N. Y. State Mus., Bull. 39.
(19) SOSHKINA, E. D., 1928, Die unterpermische Korallen vom westlichen Abhang des nördlichen Uralgebirges: Bull. Soc. Nat. Moscou. Sect. Geol. n. s., vol. 36.
(20) STUCKENBERG, A., 1895, Korallen und Bryozoen der Steinkohlenablagerungen des Ural und des Timan: Mem. Com. Geol. St. Petersburg, vol. 10, no. 3.
(21) ULRICH, E. O., 1905, in: The lead, zinc, and fluorspar deposits of western Kentucky: U. S. Geol. Survey. Prof. Paper no. 36.
(22) ——, 1917: Mississippian formations of western Kentucky: Kentucky Geol. Survey.

MANUSCRIPT RECEIVED MAY 8, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 75–80, PLS. 18, 19, JANUARY 1948

SOME ADDITIONAL CEPHALOPODS FROM THE PENNSYLVANIAN OF OHIO

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ABSTRACT—Representatives of the genera *Liroceras*, *Metacoceras*, *Domatoceras*, *Solenochilus*, *Imitoceras?*, *Eoasianites*, and *Pennoceras* are described, and two of them (*Domatoceras* and *Solenochilus*) are illustrated. Also, a new genus, *Ungeroceras*, is established for a unique cyrtoceraconic nautiloid from the Allegheny. It is concluded that cephalopods are not as rare in the Pennsylvanian strata of Ohio as has been believed.

IN 1946 we published in this Journal studies of the cephalopods of the Allegheny formation or series in Ohio. Since these reports have been issued, a considerable number of additional specimens have become available to us. One of these is unique and therefore merits special consideration. Others add to the existing information in one way or another. Also, we are including a discussion of a few Pottsville and Conemaugh specimens.

This study has confirmed the generally accepted belief that the cephalopod faunas of the Pennsylvanian of Ohio are very much like those of equivalent beds in Pennsylvania. Also, it should be emphasized that for the most part the assemblages in these two states consist of the same genera and even species as do those in the Mid-Continent region. However, cephalopods, particularly ammonoids, are considerably more abundant in the latter area, probably due to a difference in the salinity of the waters at the time of deposition of the containing sediments. That is, in general it can be said that cephalopods are abundant in the Pennsylvanian strata of Texas and Oklahoma, but they become progressively rarer with increasing distance to the north and northeast (as well as to the northwest). Inasmuch as the Pennsylvanian seas are believed to have had an open oceanic connection on the south, the water in them would presumably have been more highly saline there and would have become steadily more brackish to the north.

Nevertheless, it is becoming increasingly clear that the dearth of Pennsylvanian cephalopods in the Ohio-Pennsylvania area is somewhat more apparent than real, and careful collecting over a long period of time is certain to yield a far greater variety of both nautiloids and ammonoids than was believed to have existed there. Half of the genera of ammonoids that have been reported from the Allegheny of Ohio (that is, *Gonioglyphioceras*, *Wellerites*, and *Neoshumardites*) are known from only one or two specimens each, and none of the three listed was recorded in the literature for that state until 1946, nor has any of them been found to be represented in Pennsylvania.

Most of the material on which this report is based was collected by Sturgeon and his students. However, the fine representative of *Domatoceras* illustrated on our plate 18 was donated by Professor G. F. Lamb of Mount Union College at Alliance, Ohio; and the well preserved specimen of *Solenochilus* figured on our plate 19 was loaned for study by Professor H. F. Donner of Western Reserve University at Cleveland, Ohio. Acknowledgment is also due to Mr. Howard E. Webster of Iowa City, Iowa, who retouched the photographs that accompany this report.

SYSTEMATIC PALEONTOLOGY

Genus UNGEROCERAS Sturgeon and Miller, n. gen.

Genotype: *Ungeroceras ungeri* Sturgeon and Miller, n. sp.

The Vanport limestone has yielded a specimen that does not seem to be referable to any previously established genus. Accordingly, we here propose the name *Ungeroceras* for it, in honor of Mr. Ira Unger on whose farm the specimen was found and who for many years has been quite helpful to geologists.

The new genus can be briefly diagnosed as follows: Conch moderate in size, cyrtoceraconic, rather gradually expanded orad, compressed laterally, and broadly ellipitical in cross section. Test thick and its surface bears rather fine longitudinal and larger sinuous transverse ribs—the latter are particularly prominent on the ventrolateral zones of the conch (where they form rounded salients), and they do not extend across the dorsolateral and dorsal zones. Camerae short. Sutures form broad shallow rounded lateral lobes and corresponding dorsal and ventral saddles. Siphuncle unknown.

No forms are known to us from the Late Paleozoic that are very similar to this one, though the Mississippian of Belgium has yielded a few long slender cyrtoceracones with longitudinal markings but not with prominent transverse ribs. Of the cyrtoceracones described previously from the Pennsylvanian, *Pseudorthoceras* has only the extreme adapical portion of its conch curved, and the conch of *Poterioceras* is so rapidly expanded orad that it is breviconic.

The only known representative of this genus came from the Middle Pennsylvanian (Allegheny) of northeastern Ohio.

UNGEROCERAS UNGERI Sturgeon and Miller, n. sp.
Plate 18, figure 2

The holotype of this species is an incomplete internal mold to which an inner layer (or layers) of the test adheres—the remaining (outer) layer of the test is preserved in the "reverse" of the specimen, which is also available for study. The conch is considerably curved longitudinally, as is shown by the accompanying illustration. The overall length of the preserved portion of the holotype measures about 50 mm. This specimen was somewhat crushed and distorted during preservation, but it appears that originally its conch was slightly compressed laterally and was elliptical in cross section—the width is estimated to have been something like four-fifths the height. The conch is expanded orad rather gradually, and the height of that of the holotype increases from about 9 mm. near the adapical end of the specimen to about 15 mm. near the adoral end.

The test is moderately thick for a specimen of this size, and near the adoral end of the holotype its thickness measures almost a millimeter. The surface of the test bears fine longitudinal ribs, of which there are some 25 within the complete circumference of the conch. Also, the test bears sinuous transverse growth lines which form rounded ventral and dorsolateral sinuses and ventrolateral and dorsal salients. Along the ventral half of the lateral zones of the conch there are rounded ribs parallel to the growth lines. These curved transverse ribs, which decrease in prominence adorally, form distinct nodes on the ventral zone where they cross the longitudinal ribs, which seem to be particularly large on that part of the conch.

The camerae are short, and in the adapical part of the holotype their length averages about one-fourth their height. The sutures form broad shallow rounded lateral lobes and similar ventral saddles. No trace of the siphuncle is visible on the holotype.

Remarks.—Inasmuch as this species is the only known representative of the genus, detailed comparisons with other forms would be superfluous.

Occurrence.—Vanport limestone in the NW¼ sec. 4, Green Township, Mahoning County, Ohio.

Holotype.—Ohio State Univ., 19602.

LIROCERAS sp.

For the sake of completeness, it should be mentioned that the collections we are studying contain seven crushed fragmentary specimens that appear to belong in the genus *Liroceras*. All of them are some 25 to 35 mm. in diameter, and they all seem to have moderately large umbilici and sutures that are

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EXPLANATION OF PLATE 18

FIG. *1*—*Domatoceras williamsi* Miller and Owen, from the Lower Mercer limestone (Pottsville) near Blissville, Ohio, ×1. (p. 77)

2—*Ungeroceras ungeri* Sturgeon and Miller, n. sp., from the Vanport limestone (Allegheny) about 5½ miles north and a little east of Salem, Ohio, ×2½. (p. 76)

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1

Sturgeon and Miller, Ohio Pennsylvanian Cephalopods

Sturgeon and Miller, Ohio Pennsylvanian Cephalopods

directly transverse and straight, or nearly so.

Occurrence.—Brush Creek limestone in a road cut (the so-called White's Mill section) near the bank of Margaret Creek about one mile west of Athens, Athens County, Ohio.

Repositories.—Ohio State Univ., 19603; Ohio Univ., F-1.

METACOCERAS CORNUTUM Girty

Temnocheilus winslowi RAYMOND, 1910, Carnegie Mus. Ann., vol. 7, p. 156; ——, 1911, Pennsylvania Topog. and Geol. Surv. Comm., Rept. 1908–1910, pp. 86, 88, 90, 96.

Metacoceras cornutum GIRTY, 1911, New York Acad. Sci. Ann., vol. 21, pp. 145–146; ——, 1915, U. S. Geol. Surv. Bull. 544, pp. 11, 239, 240–242, pl. 29, figs. 4–5b; MILLER, DUNBAR, and CONDRA, 1933, Nebraska Geol. Surv., 2d ser., Bull. 9, p. 167; MILLER and UNKLESBAY, 1942, Carnegie Mus. Ann., vol. 29, pp. 128, 129, 130, 139–141, pl. 3, figs. 1–5; ——, 1947, Carnegie Mus. Ann., vol. 30, p. 322, pl. 1, figs. 9, 10.

We have three crushed fragmentary specimens that almost certainly belong in this species. Two of them are testiferous and bear a row of rather prominent longitudinally elongate rounded nodes on each ventrolateral shoulder. One of them also retains part of the umbilical shoulder, and it bears low nodes. None of these specimens is well enough preserved or complete enough to merit detailed description or illustration.

Remarks.—Although this species is abundant in the Conemaugh of western Pennsylvania, only one Ohio specimen has been recorded previously—it came from the Ames limestone in the southeastern part of the State. Some of the nautiloids listed by Morningstar from the Pottsville of Ohio and some of those listed by Mark from the Conemaugh of this State may, of course, belong in this species.

Occurrence.—Two of the specimens under consideration are from the Brush Creek limestone in a road cut (the so-called White's Mill section) near the bank of Margaret Creek about 1 mile west of Athens, Athens County, Ohio. The third specimen came from the Vanport limestone (Allegheny) on the Ira Unger farm in the NW¼ sec. 4, Green Township, Mahoning County, Ohio. Conspecific specimens have been recorded previously from the Ames limestone also in Athens County, Ohio; from the Brush Creek, Pine Creek, Woods Run, and Ames limestones (all Conemaugh) of western Pennsylvania; and the Wewoka formation of central Oklahoma.

Repositories.—Ohio State Univ., 19604; and Ohio Univ., F-2 and F-3.

DOMATOCERAS WILLIAMSI Miller and Owen
Plate 18, figure 1

Domatoceras williamsi MILLER and OWEN, 1934, Univ. Iowa Studies Nat. Hist., vol. 16, pp. 194, 195, 246–250, pl. 16, fig. 4; pl. 17, figs. 1–4; pl. 18, fig. 1.

Professor G. F. Lamb recently called to our attention and made available to us for study an essentially complete representative of *Domatoceras* from the Pottsville of central Ohio. He obtained this specimen over 30 years ago from the late Mr. R. J. Frederick, who had acquired it at still an earlier date.

This specimen is an internal mold that represents about three and a quarter volutions of the conch. One side of it was originally imbedded in a gray somewhat weathered limestone. Fragments of the test are replaced by calcite impregnated with iron oxide. All of this specimen except the adoral third of the outer volution is septate.

The conch is large, is subdiscoidal in form, and is gradually and regularly expanded orad. The diameter of the specimen under consideration, measured from the adoral end of the venter across the umbilicus, is about 130 mm. At the junction of the phragmacone and the living chamber, the conch is about 35 mm. high and 27 mm. wide. The whorls are flattened laterally and ventrally, abruptly rounded ventrolaterally and to a lesser extent dorsolaterally, and only very slightly impressed dorsally. The flattened lateral zones of the conch converge ventrad very slightly, and the maximum

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EXPLANATION OF PLATE 19

FIGS. *1, 2*—*Solenchilus greenensis* Sturgeon, from the Hamden limestone (Allegheny) near New Philadelphia, Ohio, ×1½. (p. 78)

width of the conch is therefore attained at (or near) the umbilical shoulders.

The umbilicus is large and open, and the maximum diameter attained by that of the specimen we are studying measures about 65 mm. The umbilical shoulders are rounded and the umbilical walls moderately steep. The extreme adapical portion of the conch is not very well preserved, but there appears to have been a rather large oval umbilical perforation.

A fragment of the test (or a replacement of it) is preserved on the unfigured side of the specimen. It shows that in the adoral portion of the phragmacone the test is about 1 mm. thick, and that its thickness is greater along the umbilical and ventrolateral shoulders than on the flattened lateral and ventral zones. No trace of the growth lines is discernible, but from a single preserved node on the adoral part of the phragmacone it is apparent that each ventrolateral shoulder bore a row of longitudinally elongate laterally compressed rounded nodes.

The camerae are rather short, and there are thirty of them in the adoral volution of the phragmacone. The septa are moderately convex apicad. Each mature suture consists of broadly rounded ventral, lateral and dorsal lobes, and rather narrowly rounded ventrolateral and dorsolateral saddles.

The siphuncle at maturity is subcentral in position but is located nearer the venter than the dorsum. In the adoral portion of the phragmacone, where the conch is about 32 mm. high, the siphuncle is about 4 mm. closer to the venter than to the dorsum (the bottom of the impressed zone), and it is broadly oval in cross section with diameters of about 2 mm. and 3 mm.

Remarks.—A direct comparison of this specimen with the syntypes of *D. williamsi*, which came from the Cherokee of west-central Missouri, has convinced us that there is no material difference between them. This form is also similar to the genotype, *D. umbilicatum* Hyatt of the Cherokee of Kansas, and to *D. mosquense* (Tzwetaev) of the Upper Carboniferous (Dewiatowo oölite) of central European Soviet Russia, and all of them may possibly be conspecific.

It should also be mentioned that we have available for comparison a crushed testiferous fragmentary specimen from the Lower Mercer limestone of southeastern Ohio that probably belongs in the species under consideration. It represents about half of one volution of a whorl that was some 100 mm. in diameter. Perhaps the most significant fact about this specimen is that it possesses a single row of rather prominent longitudinally elongate rounded nodes on each of its ventrolateral shoulders. It is estimated that there were some 40 of these nodes to the volution in this specimen.

Occurrence.—The figured specimen came from near Blissfield, Clark Township, Coshocton County, Ohio, presumably from the Lower Mercer limestone. The fragmentary specimen just discussed is from the Lower Mercer near Carbon Hill, Ward Township, Hocking County, Ohio.

Repositories.—Professor Lamb has kindly agreed to deposit the figured specimen in the Geological Museum of Ohio State University, where its catalogue number is 19601. The fragmentary specimen is in the Hyde Collection of Western Reserve University.

SOLENOCHILUS GREENENSIS Sturgeon
Plate 19, figures 1, 2

Solenochilus greenensis STURGEON, 1946, Jour. Paleontology, vol. 20, pp. 12, 32, 33–35, pl. 8. fig. 6; pl. 9, fig. 3.

Professor H. F. Donner kindly loaned to us for study a well preserved specimen from the Hyde Collection that is clearly referable to *Solenochilus* and appears to belong in *S. greenensis* Sturgeon. This specimen seems to represent the adoral portion of the phragmacone and the adjacent part of the living chamber. For the most part it is an internal mold, but considerable portions of the test adhere to it. Fortunately, it was not distorted during preservation.

The overall length of this specimen measures about 73 mm., and the maximum width and height of conch attained by the preserved portion are about 73 mm. and 54 mm., respectively. As is shown by the accompanying illustrations, the conch is expanded orad fairly rapidly.

The whorls are very broadly rounded ventrally and broadly rounded ventrolaterally. Laterally they are nearly flat, but they bear a rather prominent rounded ridge,

dorsad of which there is a broad concave zone, which extends to the umbilical shoulder. The dorsal side of the conch is impressed by the ventral portion of the preceding volution, but the impressed zone is relatively narrow, as the conch is rapidly expanded orad. The umbilical shoulders appear to be narrowly rounded and the umbilical walls rather steep.

The test of this specimen averages about 1 mm. in thickness, and it appears to be slightly thicker on the lateral than on the ventral zones. It bears numerous fine growth lines, which form a shallow broadly rounded ventral sinus and on either side of it a similar but smaller ventrolateral salient and lateral sinus, a small but prominent rounded salient on the lateral ridge, and apparently a rounded sinus on the lateral concave zone dorsad of the lateral ridge.

The camerae are fairly long, and along the ventral side of the specimen that we are studying the lengths of those preserved measure about 13 mm., 16 mm., and 21 mm., respectively. The sutures are directly transverse, but they are slightly sinuous, forming a low ventral saddle (which is divided medianly by the siphuncle), and on either side of it a low shallow lobe, a similar ventrolateral saddle, and a very slight lateral lobe which extends to the lateral ridge.

The siphuncle, which is rather small, is ventral and marginal in position. The septal necks appear to have the form of a truncated cone which is modified on its ventral side where it comes in contact with the shell. The connecting rings form a bulblike expansion immediately apicad of the septal necks but presumably they are essentially cylindrical throughout the rest of their length, as are those of the conspecific specimen represented by figure 3 on Sturgeon's plate 9 of 1946—in the latter specimen it can be seen that adapically the connecting rings invaginate into the septal necks and extend throughout their length. At the adapical end of the specimen we are studying, the siphuncle is subelliptical in cross section and is about 3½ mm. wide and 2¼ mm. high.

Remarks.—The fact that all three of the camerae of the above-described specimen progressively increase in length adorally suggests that it does not represent a fully mature portion of the phragmacone. Also, the syntypes show that in this species the phragmacone attained a considerably larger size.

This form is similar to the specimen from the Lower Mercer limestone of northeastern Ohio that Sturgeon (1938, pp. 277–279, pl. 1, fig. 1–3) illustrated and described as *Solenochilus peculiare* Miller and Owen, and to *S. bognari* Sturgeon of the Vanport limestone of east-central Ohio. Inasmuch as most of the representatives of *Solenochilus* known from the Pennsylvanian of Ohio are distorted, detailed comparisons are difficult and not very satisfactory. However, it should be noted that at least the Hamden and the Vanport specimens possess a dorsolateral concave zone, which suggests that they are closely related.

Occurrence.—Hamden limestone near New Philadelphia, Tuscarawas County, Ohio. The syntypes of this species came from the Hamden almost 50 miles northeast of New Philadelphia.

Hypotype.—Western Reserve Univ., 5358.

IMITOCERAS? spp.

The Washingtonville shale of northeastern Ohio contains small subglobular pyritized goniatites, of which we have a couple of dozen. All of these consist of only about one or two volutions of the conch, and they are almost certainly immature. The protoconch is ellipsoidal in shape, as it is relatively wide. The external sutures are very distinct on the best of the specimens available for study. They form small narrowly rounded or subangular ventral and lateral lobes and relatively broad rounded ventrolateral and lateral saddles.

Remarks.—Inasmuch as all these specimens are believed to be immature, we are very uncertain in regard to their generic affinities. Furthermore, it is not likely that all of them are congeneric. These are the first goniatites to be recorded from the Washingtonville shale.

Occurrence.—Washingtonville shale, NW¼ sec. 9, Center Township, Columbiana County, Ohio.

Repositories.—Ohio State Univ., 19605; and Ohio Univ., F-4.

EOASIANITES cf. E. GLOBULOSUS (Meek and Worthen)

(?) *Goniatites globulosus* MEEK and WORTHEN, 1860, Acad. Nat. Sci. Philadelphia, Pr. 1860, p. 471; ——, 1866, Illinois Geol. Surv., vol. 2, pp. 390–392, pl. 30, figs. 2a–2c; SMITH, 1894, Jour. Geology vol. 2, p. 191.

(?) *Gastrioceras globulosum* HYATT, 1884, Boston Soc. Nat. Hist., Pr., vol. 22, p. 327; SMITH, 1896, Am. Phil. Soc., Pr., vol. 35, pp. 258–260. pl. 18, figs. 1–6; ——, 1897, Leland Stanford Junior Univ. Publ., Contr. Biol. Hopkins Seaside Lab., no. 9, pp. 48–50, pl. 18, figs. 1–6; ——, 1903, U. S. Geol. Surv. Mon. 42, pp. 15, 16, 89–90, 145, pl. 6, fig. 1; pl. 21, figs. 7–9.

(?) *Glyphioceras globulosum* HAUG, 1898, Soc. géol. France, Mém., Paléont., t. 7, no. 18, p. 26.

(?) *Glaphyrites globulosus* PLUMMER and SCOTT 1937, Texas Univ. Bull. 3701, pp. 18, 30, 33, 264, 266, 269, 270, 273, 274, 275, 276–279, chart opp. p. 402, pl. 15, figs. 1–8.

Eoasianites cf. *E. globulosus* MILLER and STURGEON, 1946, Jour. Paleontology, vol. 20, pp. 385–386, pl. 56, figs. 1–3, 10, 11.

Recent collecting has yielded an additional Ohio specimen that is identical with or at least very similar to *Eoasianites globulus*. It is septate throughout and therefore represents only phragmacone, and the part of it that is preserved attained a maximum diameter of about 33 mm. Insofar as general shape of conch and umbilicus and nature of sutures are concerned, this specimen seems to resemble very closely the one from the Hamden limestone that we figured in 1946.

Occurrence.—Hamden limestone just west of Franklin Square in the NW¼ sec. 22, Salem Township, Columbiana County, Ohio. Other Ohio specimens that are believed to be conspecific are from (1) the Hamden about 2¾ miles north of the locality that yielded the specimen under consideration and (2) the Vanport limestone about 2½ miles west of Canfield, Mahoning County, Ohio.

Repository.—Ohio Univ., F-5.

PENNOCERAS SEAMANI Miller and Unklesbay

Pennoceras seamani MILLER and UNKLESBAY, 1942, Carnegie Mus. Ann., vol. 29, pp. 128, 129, 130, 146–148, pl. 8, figs. 7–13; ——, 1947, Carnegie Mus. Ann., vol. 30, pp. 325–326, pl. 1, figs. 3, 4.

Five crushed fragmentary specimens that appear to belong in this species have been found in a dark gray to black shaly phase of the Brush Creek limestone in southeastern Ohio. None of these reveals a trace of the sutures, but all show the rather prominent transverse ribs that are so characteristic of this genus and species. This ornamentation, together with the closed umbilicus and general physiognomy of the conch, makes the identification reasonably certain.

Remarks.—These specimens are the first representatives of the genus *Pennoceras* to be found outside the state of Pennsylvania. They came from the same general horizon as the Pennsylvania syntypes.

Occurrence.—Brush Creek limestone in a road cut (the so-called White's Mill section) near the bank of Margaret Creek about 1 mile west of Athens, Athens County, Ohio. The syntypes of this species were collected from the Brush Creek limestone in western Pennsylvania, and conspecific specimens have been found in the Pine Creek limestone in the same general area.

Repositories.—Ohio State Univ., 19606; and Ohio Univ., F-6.

MANUSCRIPT RECEIVED MAY 14, 1947.

REFERENCES

MARK, CLARA GOULD, 1912, The fossils of the Conemaugh formation in Ohio: Ohio Geol. Surv., 4th ser., Bull. 17, pp. 261–326, pls. 13–16.

MILLER, A. K., and OWEN, JOHN BRITTS, 1934, Cherokee nautiloids of the northern Mid-Continent region: Iowa Univ. Stud. Nat. Hist., vol. 26, pp. 185–272, pls. 8–19.

MILLER, A. K., and STURGEON, MYRON T., 1946, Allegheny fossil invertebrates from eastern Ohio—Ammonoidea: Jour. Paleontology, vol. 20, pp. 384–389, pl. 56.

MILLER, A. K., and UNKLESBAY, A. G., 1942, The cephalopod fauna of the Conemaugh series in western Pennsylvania: Carnegie Mus. Ann., vol. 29, pp. 127–174, pls. 1–8.

——, 1947, The cephalopod fauna of the Conemaugh series in western Pennsylvania—Supplement: Carnegie Mus. Ann., vol. 30, pp. 319–330, pls. 1, 2.

MORNINGSTAR, HELEN, 1922, Pottsville fauna of Ohio: Ohio Geol. Surv., 4th ser., Bull. 25, pp. 1–312, pls. 1–16.

STURGEON, MYRON T., 1938, A specimen of *Solenochilus peculiare* from the Pottsville series of Ohio: Ohio Jour. Sci., vol. 38, pp. 277–279, pl. 1.

——, 1946, Allegheny fossil invertebrates from eastern Ohio—Nautiloidea: Jour. Paleontology vol. 20, pp. 8–37, pls. 3–9.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 81–84, PL. 20, JANUARY 1948

A TRIASSIC CRINOID FROM MEXICO

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ABSTRACT—A new genus and species of the Roveacrinidae is described from the Upper Triassic of Mexico. The species is based on a large collection of free centrodorsal, radial, and brachial plates.

CRINOID remains from the Triassic are rare. Only six species, based on columnals and referred to the genera *Isocrinus* and *Encrinus* have been described from North America (Biese, 1934, and Sieverts-Doreck and Biese, 1939). Swimming and pelagic crinoids are unknown from the Triassic, the earliest records of this type occurring in rocks of Jurassic age.

In February of 1947, Dr. J. B. Reeside, Jr. of the United States Geological Survey sent the writer hundreds of associated centrodorsal, radial, and brachial plates from the Upper Triassic (Karnic) of Sonora, Mexico. These Triassic crinoids bear a marked resemblance to those from the Cretaceous of Europe and North America included in Roveacrinidae (Peck, 1943). The brachials are almost identical in construction with those described by Sieverts-Doreck (1932) from the Cretaceous of Germany. The Triassic forms lack the ornamentation possessed by the Cretaceous representatives of the Roveacrinidae, and the radials were easily separated from the centrodorsals on fossilization and occur as free plates. Another unusual character of the Triassic forms is that the radials were not in contact proximally.

Roveacrinidae have been previously recorded from the Cretaceous of England and Germany, and from the Lower Cretaceous of Texas. This record extends the range of the family from the Upper Triassic to Cretaceous. These small crinoids are probably widespread and of frequent occurrence. They undoubtedly have been noted by many investigators and identified as echinoderm fragments. The Roveacrinidae had been noted by several investigators in the Lower Cretaceous of Texas but consistently misidentified (Peck, 1943). Burckhardt (p. 6, 1930) listed bryozoa from the locality from which these Triassic crinoids were collected, but Reeside states (letter) "We found no Bryozoa in a very large and varied collection from this locality." On casual examination the coarsely porous surfaces of many of the plates, especially the centrodorsals, closely resemble the surfaces of finely branching Bryozoa. The writer believes that the Roveacrinidae will be found in many formations of the Mesozoic and that the pelagic habits and easily recognizable characters will make them valuable stratigraphic fossils.

Mrs. Vaona Hedrick Peck retouched the photographs, made the restoration drawing, and arranged the photographs on Plate 20. The retouched photographs are as accurate as it is possible to make them. With the exception of the outline drawing, no restorations or interpretations have been made.

The holotype, all figured specimens, and the bulk of the material on which this paper is based, are deposited in the U. S. National Museum. A set of paratypes is deposited in the University of Missouri Collections.

Family ROVEACRINIDAE Peck, 1943, emend.

Small, stemless, pelagic Articulata with coarsely porous calyces composed of five radial plates and noncirriferous centrodorsals. Sides of adjoining radials extended distally to form prominent processes between the arm facets. Arms ten, the division on the second brachial. Brachials joined by alternating muscular articulations and cryptosynarthial unions to $SBrBr_4$, and probably beyond. All brachials except $PBrBr_1$ and $SBrBr_1$ possess strong, distally projecting serrated processes bordering the ventral furrows.

Distribution. Upper Triassic of Mexico, Cretaceous of Europe and North America.

Discussion.—The family Roveacrinidae was defined (Peck, 1943) to contain a small group of pelagic crinoids described from Europe by Douglas (1908), Jaekel (1921), and Sieverts (1932, 1933), and from the Lower Cretaceous of Texas by Peck (1943). The family characters were based largely on the construction of the calyces and to a minor degree on the characteristics of the associated brachials. The discovery of abundant centrodorsals, radials, and brachials from the upper Triassic of Mexico has given new evidence on the interrelationships of this group of crinoids and makes possible formulation of more persistent and diagnostic family characters.

The centrodorsals of the Triassic specimens bear but slight resemblance to those previously described from the Cretaceous. The radials of the Triassic crinoids under consideration were insecurely joined to the centrodorsals and occur as free plates in the material examined. The brachial plates of the Triassic specimens with the strong distally directed serrate processes bordering the ventral furrows, and the cryptosynarthial unions in the first and second division series are almost identical with those described by Sieverts (1932) from the Cretaceous of Germany. The characters of the arms are much more persistent in this group of crinoids than the form, shape, and ornamentation of the calyces, and are considered to give a better indication of relationships.

The systematic relationships of the Roveacrinidae have been discussed by several authors. Douglas (1908) suggested a resemblance to *Extracrinus;* Jaekel (1921) and Sieverts (1932, 1933) considered them as related to the Rhizocrinidae; Bather (1928) suggested a relationship to *Phyllocrinus*; Peck (1943) compared them with the comatulids; and Sieverts-Doreck (1943) redefined the family Saccocomidae to include the genus *Roveacrinus* Douglas. The discovery of well organized representatives of the Roveacrinidae in the Upper Triassic of Mexico makes all previously suggested relationships improbable. The Roveacrinidae were highly specialized crinoids and their derivation is not clear.

The above description of the Roveacrinidae excludes representatives of the subfamily Drepanocrininae Peck (1943). The Drepanocrininae lack the strong distally directed processes bordering the ventral grooves and the prominent lateral processes on the radials. The calyces of the Drepanocrininae are composed of five radials without centrodorsals and are compact, not coarsely porous. These characters are of sufficient systematic importance to justify removing the Drepanocrininae from the family Roveacrinidae. The Drepanocrininae should probably be given family rank and renamed. Sieverts (1933) was correct in considering *Drepanocrinus* Jaekel a synonym of *Roveacrinus* Douglas, and Peck (1943) probably incorrect in reviving Jaekel's generic name for Lower Cretaceous crinoids from Texas.

Genus SOMPHOCRINUS[1] Peck, n. gen.

Elongate, small to medium size Roveacrinidae with radials joined to centrodorsals by syzygial union along small triangular surfaces. Radials in contact only along lateral processes. Centrodorsals conical to cylindrical with flaring distal ends on which are five flattened triangular areas for reception of proximal ends of radial plates.

Genotype: *Somphocrinus mexicanus* Peck from the Upper Triassic of Mexico.

SOMPHOCRINUS MEXICANUS Peck, n. sp.
Plates 20, figures 1–38

Small to medium size crinoid crowns known only from associated centrodorsal, radial, and brachial plates. Complete crowns of the largest individuals attained a maximum length of about 25 to 30 mm. and the diameter, measured at the distal ends of the radials, was probably never more than 5 mm.

The centrodorsals are conical to cylindrical in shape, expanded distally with truncate distal ends and pointed to rounded proximal ends. The distal ends are pentagonal and have five flattened to slightly concave triangular elevated areas for attachment of the radials. The radial attachment areas are at right angles to the long axis of the centrodorsal or slope of the exterior. Situated in

[1] σομφός—porous.

the center of the distal surface and between the inner points of the radial attachment areas is a shallow depression—the proximal cavity. The surfaces are rough and coarsely porous.

The radials are roughly triangular in shape, tapering from the distal arm facets to the small flattened areas for syzygial union with the centrodorsals, thicker than wide proximally, thickness and width about equal at the distal ends. Starting just above the proximal ends of the radials on the ventral side are ridges that broaden distally and are extended beyond the radial arm facet into strong processes. These processes are beveled along their ventral lateral edges for union with processes of adjoining radials. The arm facets are well developed with large and fairly deep ligament pits. The central canal is located just ventral to the prominent transverse ridge, and penetrates the radial for about two-thirds the total length to a point on the ventral side. The interarticular ligament fossae and dorsal ligament fossae occupy most of the facet. Muscular fossae are well developed.

The $PBrBr_1$ are wedge-shaped with the articulation surfaces for the radials on the proximal ends, and the distal ends beveled to the exterior for the strongly sloping cryptosynarthial union with $PBrBr_2$. The interiors of $PBrBr_1$ are ornamented by forked ridges originating at the proximal ends and almost immediately dividing, the two ends terminating at the lateral margins of the plates about two-thirds the distance from the proximal ends. The ventral areas outside the forked ridge are flattened to fit into the distal processes of the radials. The central canals are located about the centers of the cryptosynarthial surfaces. Distally directed processes are absent on $PBrBr_1$.

The $PBrBr_2$ are axial, triangular in shape, tapering from the broad distal ends to the almost pointed proximal ends of the cryptosynarthial surfaces. Distally directed serrated processes are strong, prominent, and separated by a strong distally directed spine. The facets for articulation of $SBrBr_1$ are asymmetrical with the central canals penetrating the transverse ridges near the inside border of each facet. The ligament pits are large and deep.

The $SBrBr_1$ are comparatively long, wedge-shaped, slightly twisted, asymmetrical plates with the central canals displaced laterally to fit the articulation surfaces on $PBrBr_2$. The ventral furrows are bordered by serrated ridges tapering to points near the distal ends of the cryptosynarthial surfaces and not extended into processes. $SBrBr_1$ resemble $PBrBr_1$ in general shape and configuration but the $PBrBr_1$ lack the asymmetry, twisted appearance, and serrate ventral surfaces.

The $SBrBr_2$ are elongate, wedge-shaped plates closely resembling $PBrBr_2$ but are not axial. The $SBrBr_2$ are slightly asymmetrical proximally on the cryptosynarthial union with $SBrBr_1$, but are perfectly symmetrical distally. The serrate processes are strongly developed. The ligament pit is large and elliptical, the long axis of the ellipse parallel to the transverse ridge.

The $SBrBr_3$ are quadrangular in shape, truncated distally by the cryptosynarthial surface sloping slightly toward the exterior. Serrated processes are well developed.

The $SBrBr_4$ are quadrangular in shape, truncated proximally by cryptosynarthial surface and distally by the muscular articulation surface. The serrated processes are strongly developed.

The SBrBr distal to $SBrBr_4$ cannot be differentiated from $SBrBr_3$ and $SBrBr_4$.

Types.—The holotype, a centrodorsal, and all figured paratypes are deposited in the U. S. National Museum. The holotype is numbered 104235 and the paratypes 104236a-z, 104237a-i. A set of paratypes is deposited in the University of Missouri Collections, numbers E–26–1 to E–26–9.

Occurrence.—Lower part (Karnic) of Upper Triassic, U.S.G.S. Mesozoic locality, 18950. Cerro Colorado (or Cerro de la Cruz) about 150 meters east of El Antimonio, Sonora, Mexico. Collected by D. E. White and G. A. Cooper.

Discussion.—The above description is based on the study of several hundred free centrodorsals, radials, and brachial plates. The centrodorsals vary considerably in size and shape, and to some extent in texture and porosity of the exterior surface. The radials and brachials also vary in character but the variations are not as conspicuous as those of the centrodorsals. Considering that all of the material came from a single

locality it is possible that these are normal variations within a species.

REFERENCES

BURCKHARDT, CARLOS E., 1930, Étude synthétique sur le Mésozoique: Soc. paléont. Suisse Mem., vol. 49, p. 6.

CLARK, AUSTIN H. 1915, 1921, 1931, A monograph of existing crinoids: U. S. National Museum Bull. 82, pts. 1, 2, 3.

CLARK, W. B. and TWITCHELL, M. W., 1915, The Mesozoic and Cenozoic Echinodermata of the United States: U. S. Geol. Survey Monograph 54.

BIESE, WALTER, 1934, Crinoidea triadica: Fossilium Catalogus, Animalia, Pars. 66.

DOUGLAS, J. A., 1908, A note on some new chalk crinoids: Geol. Magazine, n. ser. Decade 5, vol. 5, pp. 357–359.

GISLEN, TORSTEN, 1924, Echinoderm Studies: Zoologiska Bidrag Fran Upsala, Band 9.

JAEKEL, OTTO, 1921, Phylogenie and System der Pelmatozoen: Palaeont. Zeitschr., vol. 3, p. 72.

PECK, RAYMOND E., 1943, Lower Cretaceous crinoids from Texas, Jour. Paleontology, vol. 17, pp. 451–475.

SIEVERTS-DORECK, HERTHA, and BIESE, WALTER, 1939, Supplementum ad Crinoidea triadica, jurassica, cretacea, et caenozoica: Fossilium Catalogus, Animalia, Pars 88.

SIEVERTS, HERTHA, 1932, Über die Crinoidengattung *Drepanocrinus* Jaekel: Preuss. geol. Landesanstalt Jahrb., vol. 53, pp. 599–610.

——,1933, *Drepanocrinus* Jaekel, ein Synonym von *Roveacrinus* Douglas, und ein neuer Vertreter dieser Gattung aus der deutschen Kreide: Centralb. Mineralogie, Abt. B., pp. 54–59.

SIEVERTS-DORECK, HERTHA, 1943. Armglieder von *Roveacrinus* aus einem norddeutschen Senongeschiebe: Zeitschrift für Geschiebeforschung und Flachlandsgeologie, vol. 18, pp. 228–231.

MANUSCRIPT RECEIVED MAY 20, 1947.

EXPLANATION OF PLATE 20

All figures ×10 except Figs. 1 and 33. All figured specimens in U. S. National Museum Collections.

FIGS. *1–38*—*Somphocrinus mexicanus* Peck, n. sp. (p. 82)

1—Drawing to represent author's conception of assembled plates.
2—Exterior view of SBr_4.
3—Distal view of SBr_2.
4—Summit of centrodorsal showing proximal cavity and slightly concave syzygial areas for attachment of radials.
5—Lateral view of small centrodorsal.
6—Side view of SBr_3.
7—Interior (ventral) view of SBr_3 and SBr_4 joined by cryptosynarthy. Surface is weathered.
8—Exterior view of SBr_3.
9, 10, 11—Exterior, interior, and lateral views of $SBrBr_2$.
12, 13—Lateral views of centrodorsals.
14—Exterior of SBrBr joined by cryptosynarthy.
15—Lateral view of holotype, a centrodorsal. Some of the triangular facets are broken.
16—Interior view of SBr_4.
17—Summit of centrodorsal.
18—Lateral view of SBr_1.
19, 20—Interior and exterior views of right-hand $SBrBr_1$.
21—Exterior of left-hand SBr_1.
22—Exterior view of small SBr_2.
23, 24—Exterior and interior views of $PBrBr_2$.
25—Interior view of SBr_1.
26—Exterior of small PBr_2.
27—Exterior of SBrBr joined by cryptosynarthy.
28, 29—Exterior and interior views of small $PBrBr_1$.
30, 31, 32—Lateral, interior, and exterior views of $PBrBr_1$.
33—Series of plates from radial to $SBrBr_4$ to give reconstruction of arm—the plates did not all belong to the same crinoid ×5.
34, 35, 36—Exterior, interior, and lateral views of radial plates.
37—Lateral view of SBrBr joined by cryptosynarthy and showing strong serrate processes.
38—Lateral view of centrodorsal.

Figures 34, 32, 23, 20–21, 9, 8, and 2 are arranged in vertical order to show exterior views of succession of plates from radial to SBr_4. Figures 35, 31, 24, 19, 10, and 7 are arranged to show interior views of succession from radial to SBr_4. Figures 36, 30, 18, 11, 6 are arranged to show lateral view of succession from radial to SBr_3 with PBr_2 missing in the series.

Peck, Triassic Crinoid from Mexico

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 85–90, PL. 21, JANUARY 1948

EOCENE CHAROPHYTA FROM NORTH AMERICA

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ABSTRACT—Charophyte oogonia from the Eocene of Florida, Utah, and Wyoming are described. The characteristics of lower Cenozoic Charophyta and their value as stratigraphic fossils are discussed. Four new species are defined.

INTRODUCTION

CHAROPHYTE oogonia and fresh-water ostracodes have contributed greatly to the correlation of continental deposits of Jurassic and Lower Cretaceous age in North America, and have added to our knowledge of the lower Cenozoic deposits of Europe, India, and South America. Both charophyte oogonia and ostracodes occur in abundance in continental deposits of the late Cretaceous and early Cenozoic in the Rocky Mountain area of North America, but detailed studies of their ranges and distribution have not been made.

Fossil charophyte oogonia were recognized in Europe as early as 1804 and by 1850 several species had been described. From 1855 to 1883 Heer prepared a series of monographs on the paleobotany of parts of Europe in which a great number of species were described and illustrated. After these extensive reports of Heer, interest lagged until Dolfuss and Fritel (1919) catalogued the lower Cenozoic oogonia of the Paris Basin in France. This was followed by comprehensive papers by Reid and Groves (1921) and Groves (1926) on Eocene and Oligocene charophytes from England. Recently a considerable collection of oogonia have been described from the Eocene of India by Sripada Rao and Nayarana Rao (1939), from the Miocene of Austria by Rasky (1941), and from lower Cenozoic deposits of Peru by Peck and Reker (1947).

The lower Cenozoic Charophyta from India, Central Europe, France, England, South America, and North America possess in common a number of characteristics which allow them to be readily recognized. Oogonia with calcified coronula cells, the rosettes or swollen tips of Groves (1926), are not known in rocks older than Eocene or younger than Oligocene. Tuberculate oogonia are likewise restricted to the Eocene and Oligocene, although one species, *Chara bleicheri* Saporta, from the Jurassic of France is reported to be tuberculate. The writers seriously question the tuberculate nature of *C. bleicheri* and suggest that possibly this species is a representative of the Clavatoraceae Pia with the utricle exfoliated and the oogonium weathered (see Peck, 1941, pl. 42, fig. 30).

Fossil charophyte oogonia are difficult to classify. According to Groves (1926) there is little variation in the size of oogonia belonging to a single modern species, but the writers hesitate to use size as a specific character in fossil forms unless it is marked and consistent in a considerable number of specimens. In many collections oogonia otherwise similar will show a great variation in the amount of calcite secreted by the enveloping cells and will possess either cellular ridges or intercellular ridges. The shape of oogonia within a species should be consistent unless it has been modified by pressure of enclosing sediments. In general, the writers have used size, shape, and number of spirals visible in a lateral view as specific characters. It is believed that these characters are of value for systematic differentiation when large collections of oogonia are at hand for study. We have consistently declined to recognize a variation as of specific value unless we had more than 10 specimens in which the variation could be recognized.

Considering the difficulty of establishing fine divisions in the classification of the Charophyta, it is believed that they will never be of value for the discrimination of small stratigraphic units. Yet they are of real value in period differentiation: conti-

nental deposits of Jurassic, Lower Cretaceous, Cretaceous, and lower Cenozoic ages can be readily differentiated on the basis of charophyte oogonia. At present it is not possible to use the oogonia in separating Eocene and Oligocene deposits.

The writers take pleasure in expressing their gratitude to Dr. J. B. Reeside, Jr. of the United States Geological Survey for the topotype specimens of *Chara compressa* Knowlton; to Dr. Herman Gunter of the Florida Geological Survey and Dr. A. G. Unklesbay of the University of Missouri for the opportunity of studying the oogonia from Florida; and to Mrs. Vaona Hedrick Peck for retouching and arranging the photographs on the plate. The charophyte oogonia from Utah and Wyoming were collected by the senior author.

COLLECTING LOCALITIES

Lower Wasatch.—Samples 22P, 23P, 24P, 25P, and 26P, taken in ascending order from a section with many limestones, some fossiliferous, and grey shales below most of the red coloration characteristic of the Wasatch. Samples taken along the Castlegate-Duchesne road, Utah State Highway #33, eight miles north of Castlegate, Utah.

Evanston formation (Hoback formation of University of Michigan).—Samples 52P and 53P were taken near the head of a small stream running past the Hoback Guard Station on the west side of Hoback Canyon (Fall River Canyon of Schultz, 1914) in the NW¼ Section 31, T. 38N., R. 113W., Sublette County, Wyoming.

Sample 52P was taken above and below a fresh-water limestone containing many charophyte oogonia.

Sample 53P was taken under a fossiliferous sandstone about 100 feet below sample 52P.

Sample 54P was taken from a horizontal series of sandstones, shales, and limestones on the west side of Bondurant Creek (Cliff Creek of Schultz, 1914) one-half mile south of Hoback Canyon (Fall Creek Canyon of Schultz, 1914) in T. 38N., R. 114W., Sublette County, Wyoming.

Sample 55P was taken near a fossiliferous sandstone ledge about ½ mile upstream from sample 54P.

Samples 102P and 103P were taken on the west side of Bondurant Creek (Cliff Creek of Schultz), about 3 miles below the VV Ranch, T. 38N., R. 114W., Sublette County, Wyoming. Samples were taken about 40 feet apart (vertically) below a limestone slump about 150 feet east of Evanston-Triassic contact. Probably near the base of the Evanston.

Flagstaff formation.—Samples 65P, 66P, 67P, 68P, and 69P, were taken in ascending order, starting near the base of the Flagstaff limestone one mile east of Ephriam, Utah. Samples were taken from shale beds and shale partings.

Near an old coal mine shaft, two miles west of Wales, San Pete Valley, Utah. Topotype material of *Chara compressa* Knowlton.

Ocala formation and immediately below the Ocala.—Samples were taken from wells near Orlando, Orange County, Florida. Most of the samples were from a soft cream to white limestone, containing fragments of echinoids, *Dictyoconus cookei*, *Lituonella* sp. and *Camerina* sp. The well numbers and depths of the samples are as follows:

W— 80 at 210 feet
W—141 at 291 feet
W—367 at 200–270 feet
W—369 at 230–240 feet
W—804 at 255 to 350 feet
W—809 at 255 to 275 feet and at 405 feet. These cuttings were from below the Ocala.

SYSTEMATIC DESCRIPTIONS

CHAROPHYTA

Family CHARACEAE

Genus CHARA Vaillant, 1719

CHARA INCONSPICUA Unger

Plate 21, figures 12–15

Chara inconspicua UNGER, 1850, Genera et Species Plantarum Fossilium, Vindobonae, p. 34.

Chara inconspicua GROVES, JAMES, 1933, Fossilium Catalogus, II, Plantae, pars 19, p. 21.

Chara inconspicua RASKY, KLARA, 1941, Sonder-

druck aus Földtani Közlöny Band 71, p. 301, pl. 7, fig. 5.

Oogonia small, 0.42 mm. to 0.52 mm. in length, and 0.33 mm. to 0.42 mm. in width, broadly ellipsoid to almost spherical. Spiral ridges cellular or intercellular, the latter more common, ten to twelve spirals visible in lateral view. Basal tip slightly extended on some specimens.

Remarks.—It is not certain that the North American form here described is identical with Unger's *C. inconspicua*, although it fits the brief description given by Unger, and appears similar to the specimens figured by Heer (1855, Taf. 4, fig. 7) and Rasky (1941, Taf. 7, fig. 5). On the basis of slight differences in size, shape, and number of volutions it does not seem practical at this time to establish the North American form as a distinct species.

A number of specimens have been found which are somewhat smaller than the common dimensions given above. They nevertheless agree with *C. inconspicua* in all other observed characters, and are considered immature representatives of the species.

Types.—Location of primary types unknown. Figured specimens, numbers 31020–4, 31020–5, 31021–1, 31021–2, University of Missouri.

Occurrence.—Miocene of Europe. Very common in Lower Wasatch and Flagstaff formations, lower Eocene, of Utah. Rare in Evanston formation, lower Eocene, of Wyoming. Obtained from the following samples: 22P, 23P, 24P, 25P, 26P, 54P, 55P, 65P, 66P, 67P, 68P, 69P.

CHARA BISULCATA Peck and Reker, n. sp.
Plate 21, figures 8–11

Oogonia of medium size, 0.71 mm. to 0.78 mm. long, 0.52 mm. to 0.63 mm. wide, obovoid, with a distinct taper toward the base. Ten to twelve spirals visible in a lateral view, ridges intercellular. On most specimens prominent, regular to irregular, secondary ridges are developed along the centers of the cellular furrows. Tubercles inconspicuous and rare.

Remarks.—This description is based on approximately 50 specimens which show only slight variation in size and shape.

Most representatives of *C. bisulcata* appear to have double furrows due to the development of secondary ridges in the cellular furrows. Such secondary ridges are not restricted to *C. bisulcata* but on no other recorded species do they have the same prominence and persistence. Reid and Groves (1921, p. 185) noted a similar character in their *C. vasiformis*, but they found it rare and poorly developed.

The secondary ridges undoubtedly represent a stage in the calcification of the spiral cells of certain species and are therefore not a reliable specific character. Nevertheless, their prominence and almost universal occurrence on *C. bisulcata* afford that species a recognizable individuality.

Tubercles are poorly developed on *C. bisulcata*, and where present they are only slight irregularities or swellings along the secondary ridges.

Types.—Holotype, number 31021–3; Paratypes, numbers 31021–4, 31021–5, 31022–1; University of Missouri.

Occurrence.—Lower Eocene. Lower Wasatch and Flagstaff formations, Utah. Obtained from the following samples: 22P, 23P, 24P, 25P, 26P, 66P, 67P, 68P.

Genus ACLISTOCHARA Peck, 1937, emend. 1941

ACLISTOCHARA COMPRESSA (Knowlton)
Plate 21, figures 31–33

Chara compressa KNOWLTON, 1888, Bot. Gazette, vol. 13, pp. 156–157, figs. 1, 2.
Chara compressa GROVES, JAMES, 1933, Fossilium Catalogus, II, Plantae, pars 19, p. 14.

Oogonia large, 0.88 mm. to 0.98 mm. in length and 1.16 mm. to 1.20 mm. in width, oblate, with greatest diameter at midlength. Summit truncate, coronula prominent, separated from convex portion of spirals by a deep depression. Eight to ten convolutions between base and summit, not all visible in lateral view because of broad, flattened base and summit. Spirals consist of either cellular ridges or furrows, both present on a few specimens.

Remarks.—The above description is based on about 20 topotype specimens furnished by Dr. J. B. Reeside, Jr. of the U. S. Geological Survey. The oogonia occur in a dark fine-grained limestone and the majority of the specimens studied were freed from the matrix by crushing the limestone.

The oblate shape of *A. compressa* is distinctive. The species is closely related to *Chara oehlerti* Dollfus from the Oligocene of France but the spirals of *C. oehlerti* show only five convolutions.

Types.—Primary types probably in the U. S. National Museum. Figured specimens, numbers 31022–3 to 31022–5, University of Missouri.

Occurrence.—Flagstaff limestone, lower Eocene, two miles west of Wales, Utah, near an old coal opening.

ACLISTOCHARA CLIVULATA Peck and Reker, n. sp.
Plate 21, figures 1–7

Oogonia of medium size, spherical or nearly so, 0.65 mm. to 1.00 mm. in length and width. Coronula separated from convex ends of the spirals by a depression. Nine or ten spirals visible in a lateral view. Prominent regularly arranged tubercles present, their shape and the distance between them somewhat variable; few specimens without tubercles. Intercellular ridges common, but often obscured by tubercles.

Remarks.—The above description is based on more than 100 specimens made available for study by Dr. Herman Gunter of the Florida Geological Survey and Dr. A. G. Unklesbay of the University of Missouri.

The spherical shape of *A. clivulata* readily distinguishes it from all other recorded North American Cenozoic charophytes. *Chara archiaci* Watelet from the Cenozoic of Europe is similar in appearance, but is considerably larger, is not tuberculate, and has one or two more volutions visible in a lateral view. Described tuberculate oogonia differ markedly in size or shape from *A. clivulata*.

Tubercles may have little if any systematic value in the classification of the charophytes, but the conspicuous and almost universal development of tubercles on *A. clivulata* is undoubtedly of value in recognizing the species as far as it is known. It is not unlikely that a tendency to develop tubercles is restricted to certain species and that environment controls the expression of the inherent tendency. Stage of growth may also be a factor in their development, as has been suggested by Scourfield (in Reid and Groves, 1921, p. 185).

Types.—Holotype, number S–3241; paratypes, number S–3240, and S–3242 to S–3246; Florida Geological Survey Museum.

Occurrence.—Middle Eocene of Florida. Ocala limestone and a limestone below the Ocala. The oogonia were evidently carried into a marine environment by currents.

ACLISTOCHARA CORONATA Peck and Reker, n. sp.
Plate 21, figures 21–30

Oogonia of medium size, 0.70 mm. to 0.94 mm. in length, and 0.65 mm. to 0.84 mm. in width. Broadly ovoid to subcylindrical, with greatest width above middle. Summit

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EXPLANATION OF PLATE 21
All figures ×30

Figured specimens 1–7 in Florida Geological Survey Museum. All others in University of Missouri collections.

FIGS. *1–7*—*Aclistochara clivulata* Peck and Reker, n. sp. *1, 4, 7*, lateral views of paratypes, wells W-369, W-804, and W-80. *2*, basal view of holotype, well W-809 at 255 to 275 feet. *3, 6*, summit views of paratypes, wells W-369 and W-80. *5*, basal view of paratype, well W-80. (p. 88)

8–11—*Chara bisulcata* Peck and Reker, n. sp. *8, 9*—lateral views of paratypes, sample 67P. *10*, basal view of paratype, sample 66P. *11*, summit view of holotype, sample 68P. (p. 87)

12–15—*Chara inconspicua* Unger. *12, 13, 14*, lateral views, samples 25P, 65P, and 23P. *15*, summit view, sample 23P. (p. 86)

16–20—*Aclistochara milella* Peck and Reker, n. sp. *16, 17, 20*, summit views of paratypes, samples 102P, 55P, and 103P. *18*, lateral view of paratype, sample 55P. *19*, lateral view of holotype, sample 103P. (p. 89)

21–30—*Aclistochara coronata* Peck and Reker, n. sp. *21*, basal view of paratype, sample 54P. *22, 24, 25, 30*, lateral views of paratypes, sample 54P. *23, 27*, lateral views of paratypes, samples 53P and 67P. *26, 29*, summit views of paratypes, samples 53P and 54P. *28*, summit view of holotype, sample 53P. (p. 88)

31–33—*Aclistochara compressa* (Knowlton). Lateral, basal, and summit views. (p. 87)

Peck and Reker, Eocene Charophyta

truncate and coronulate, a conspicuous depression existing between the coronula and the convex portion of the spiral cells. Six to eight spirals visible in lateral view, with spiral cells exhibiting various stages of calcification from cellular furrows to cellular ridges. Regularly arranged tubercles developed on some specimens.

Remarks.—This description is based on over 200 well-preserved oogonia from several localities. The possession of a coronula is universal in the species, although on some specimens the coronula has been lost and the summit appears flat, truncated, or somewhat depressed.

The degree of calcification displayed by members of the species is quite probably due to environment, at least in part. It has been noted that the majority of the specimens of *A. coronata* from any one locality tend to exhibit the same stage of calcification: either cellular furrows are predominant, or cellular ridges are predominant. A common intermediate stage of calcification presents a small secondary ridge within the cellular furrow, similar to that noted in the description of *Chara bisulcata* Peck and Reker. Often this secondary ridge is nodose at regular or irregular intervals.

Tubercles are seldom conspicuous on *A. coronata*. In some specimens they appear to be definitely related to the development of the secondary ridge; in other specimens, particularly those with well-developed cellular ridges, such a relationship cannot be observed.

Types.—Holotype, number 31023–1; paratypes, number 31023–2 to 31023–5 and 31024–1 to 31024–5; University of Missouri.

Occurrence.—Lower Eocene. Very common in the Evanston (Hoback) formation, Wyoming, the Lower Wasatch and Flagstaff formations, Utah. Obtained from the following samples: 23P, 24P, 52P, 53P, 54P, 55P, 65P, 66P, 67P, 68P, 69P, 102P, 103P.

ACLISTOCHARA MITELLA Peck and Reker, n. sp.
Plate 21, figures 16–20

Oogonia of medium size, 0.65 mm. to 0.73 mm. long, 0.52 mm. to 0.63 mm. wide, obovoid, with base normally projecting. Coronula cells present, but not conspicuous on some specimens. Nine or ten spirals visible in lateral view, with cellular ridges normally present.

Remarks.—More than 100 specimens of *A. mitella* have been examined. All have a somewhat rough exterior which is evidently the result of weathering.

The development of the coronula is well displayed on most specimens. A few oogonia have no apparent expansion at the summit, but it is possible in these oogonia that the coronula cells are obscured by the weathered condition of the specimens.

The slight basal projection is a constant character of *A. mitella*, and where absent has probably been lost through weathering. Cellular furrows are rare. A few individuals show a very weak development of tubercles along the cellular ridges.

The shape of the species is variable, some of the specimens being much broader than normal. But gradations exist, indicating the single identity of the representatives.

Types.—Holotype, number 31025–1; paratypes, number 31025–2 to 31025–5; University of Missouri.

Occurrence.—Common in the Evanston (Hoback) formation, lower Eocene, Sublette County, Wyoming. Obtained from the following samples: 55P, 102P, 103P.

REFERENCES

COOKE, C. WYTHE, 1945, Geology of Florida: Florida Geol. Survey Bull. 29.

DOLFUSS, G. F., 1921, Étude Paléontologique des Marnes Oligocenes de Thevalles près Laval (Mayenne): soc. géol. et Min. de Bretagne, Bull., T. II, pp. 75–96. pl. 1.

DOLFUSS, G. F. and FRITEL, P. H., 1919, Catalogue Raisonné des Characeae fossiles du Bassin de Paris: Soc. géol. France, Bull. ser. 4, vol. 19, pp. 243–261, text figs. 1–23.

FRITZSCHE, C. H. 1924, Neue Kreidefaunen aus Sud-Amerika (Chile, Bolivia, Peru, Colombia): Neues Jahrb., L, Beilage-Band, p. 28, pl. 2, figs. 2–3.

GROVES, JAMES, 1925, Fossil Charophyte-fruits from Texas: Am. Jour. Sci. 5th ser. vol. 10, pp. 12–14, textfigs. 1–3.

GROVES, JAMES, 1926, in Reid, E. M. and Chandler M. E., Catalogue of Cainozoic Plants in the Department of Geology, British Museum of Natural History, The Bembridge Flora, vol. 1, pp. 165–173, pl. 12, figs. 1–9.

——, 1933, Charophyta: Fossilium Catalogus, II, Plantae, pars 19, W. Junk, Berlin. Contains complete bibliography and synonymies to 1933.

HEER, O., 1855, Flora Tertiaria Helvetiae I. Wintherthur.

——, 1859, Flora Tertiaria Helvetiae III. Winterthur.

——, 1865, Die Urwelt der Schweiz. Zurich. A complete bibliography of Heer is given in Groves (1933).

KNOWLTON, F. H. 1888, Description of a new fossil species of the genus *Chara:* Bot. Gazette, vol. 13, pp. 156–157, textfigs. 1–2.

——, 1893, Description of a new fossil species of *Chara:* Bot. Gazette, vol. 18, pp. 141–142, textfigs. 1–3.

PECK, RAYMOND E., 1937, Morrison Charophyta from Wyoming: Jour. Paleontology, vol. 11, pp. 83–90, pl. 14.

——, 1941, Lower Cretaceous Rocky Mountain nonmarine microfossils: Jour. Paleontology, vol. 15, pp. 285–304, pl. 42.

——, 1944, in Shimer, H. W. and Shrock, R. R. Index fossils of North America: p. 713, pl. 303, figs. 4–9.

——, 1946, Fossil Charophyta: Am. Midland Naturalist, vol. 36, pp. 275–278, textfig. 4.

——, and REKER, CARL C., 1947, Cretaceous and Lower Cenozoic Charophyta from Peru, South America: Am. Mus. Novitates. No. 1369, pp. 1–6, 27 figs.

RASKY, KLARA, 1941, Uber die Früchte Fossiler Chara-Arten aus der Tiefgohrung Nr. 11, im Stadtwäldchen von Budapest und aus den Bohrungen auf Trinkwasser in Pecs: Sonderdruck aus Földtani Közlöny (Geologische Mitteilungen) (Zeit. der Ungarischer Geologischen Gesellschatt) Band 71, Heft 7–12, pp. 297–307, pl. 7.

SAHNI, B., and NARAYANA RAO, S. R., 1943, On *Chara sausani*, nov. sp., A *Chara* (sensu stricto) from the Intertrappeans Cherts at Sausan in the Deccan: Nat. Acad. Sciences India, Proc. vol. 13, pt. 1, pp. 36–75.

SCHULTZ, A. G., 1914, Geology and Geography of a portion of Lincoln County, Wyoming: U. S. Geol. Survey Bull. 543.

SOWERBY, J. de C., 1840, Organic remains collected by Mr. Malcolmson and described and engraved by J. de C. Sowerby: Geol. Soc. Trans. ser. 2, vol. 5, pl. 47, fig. 1.

SPIEKER, E. M., 1946, Late Mesozoic and early Cenozoic history of central Utah: U. S. Geol. Survey Prof. Paper 205-D.

SRIPADA, RAO, K., and NARAYANA RAO, S. R., 1939, The Fossils Charophyta of the Deccan Inter-Trappeans near Razahmundry (India): India Geol. Survey Mem., Palaeontologia Indica, new series, vol. 29, Mem. 2.

UNGER F., 1850, Genera et Species Plantarum fossilium. Vindobonae, pp. 31–36.

MANUSCRIPT RECEIVED JUNE 4, 1947.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 91–93, PL. 22, JANUARY 1948

EOCENE ECHINOIDS FROM PANAMA

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DURING World War II fossil echinoids were noticed at Madden Airfield, Panama, by T. F. Thompson, Chief Geologist of the Panama Canal. Mr. Thompson returned there with W. P. Woodring and J. R. Schultz in February 1947, when the species listed herein were collected.

Madden Airfield, now unused, lies 15 miles north of the central part of Panama City and 6 miles northeast of the Canal Zone. Collection USGS 16889 was taken about 1000 feet north of the north end of the paved runway. The echinoids occur in limestone that comprises part of the late Eocene formation bearing the foraminiferal faunas recorded by Vaughan (1926) and by Coryell and Embich (1937).

Collection 16889 includes representatives of five species of echinoids, namely *Peronella dalli* (Twitchell), *P. acuñai* (Lambert), *P. cubae* Weisbord, *Schizaster armiger* Clark, and *Eupatagus clevei* (Cotteau). Four of these species occur also in the Ocala limestone of Florida, which is of late Eocene age, two were described from late Eocene deposits of Cuba, one from the Eocene St. Bartholomew limestone of the British West Indies. They yield strong corroboration of the late Eocene age of the limestone in Panama.

Though this is believed to be the first published record of Eocene echinoids in Panama, the collections in the United States National Museum include a few specimens collected many years ago in Los Santos Province, evidently from late Eocene limestone assigned to the David formation by Olsson (1942). A fragment of *Eupatagus clevei* (Cotteau) was found in 1917 by W. P. Woodring on Rio Tonosí 300 feet below the mouth of Quebrada Guerita (USGS 8289). In 1917 D. D. Condit collected *Oligopygus hypselus* Arnold and Clark? (1927) on Rio Guaniquito and its tributary Quebrada San Francisco (USGS 8283, 8285), and in 1919 A. A. Olsson obtained *Oligopygus cubensis* Lambert? (1931) from Rio Joaquin. These specific identifications of *Oligopygus* are only tentative because authentic examples for comparison are wanting.

PERONELLA CUBAE Weisbord

Peronella cubae WEISBORD, 1934, Bull. Am. Paleontology, vol. 20, no. 70-C, p. 217 (53), pl. 24 (5), figs. 4–6.
Peronella quinquenodulata WEISBORD, 1934, *idem*, p. 214 (50), pl. 24 (5), figs. 1–3.
Peronella caribbeana WEISBORD, 1934, *idem*, p. 216 (52), pl. 24 (5), figs. 7–9.
Peronella cubae Weisbord. COOKE, 1942, Jour. Paleontology, vol. 16, no. 1, p. 25, pl. 2, figs. 15–21.

One small corroded individual represents this species or possibly *Peronella crustuloides* (Morton). *P. cubae*, described from late Eocene deposits of Cuba, is very common in the Ocala limestone of Florida.

PERONELLA DALLI (Twitchell)
Plate 22, figures 5, 6

Laganum dalli TWITCHELL in CLARK and TWITCHELL, 1915, U. S. Geol. Survey Mon. 54, p. 164, pl. 75, figs. 4a–d.
Echinodiscus dalli (Twitchell). LAMBERT and THIÉRY, 1925, Nomenclature raisonnée des échinides, fasc. 9, p. 581.
Laganum dalli Twitchell. COLE and PONTON, 1932, Am. Jour. Sci., ser. 5, vol. 24, p. 23, fig. 1.
Peronella dalli (Twitchell). COOKE, 1942, Jour. Paleontology, vol. 16, no. 1, p. 26.

The type of this species, reported to be from Archer, Florida, is subpentagonal, discoid, with thick, rounded margin. Its apical center is tumid, with four genital perforations, which lie rather far apart though not as far from the center as the inner ends of the petals. The ocular pores are very small and inconspicuous. The petals are short, blunt, rounded, open at the inner ends, nearly closed at the outer ends. The poriferous zones are nearly as wide as the interporiferous zones; the inner row is lanceolate, composed of small round pores; the outer row expands to a rounded tip, its slot-shaped pores end at a groove, which extends almost to the inner pore. The bottom of the type is slightly concave; the central part,

including the peristome, is broken as far as the periproct, which is circular, fairly large, and lies slightly less than halfway to the center. The surface, including the interporiferous areas and the apical plates, is covered with rather large scrobiculate tubercles, which are somewhat closer together on the bottom than on the top. The type measures 15.9 by 14.9 by 4.6 mm.

Peronella dalli is represented in the collection from Panama by about 120 individuals, which range in size from as big as the type to half as large. They show that the peristome is pentagonal, slightly larger than the periproct; it has a sunken rim containing two pores in each ambulacral area. This rim is visible on the inside as a raised band adjacent to the five auricles, which project upward at the corners at a high angle. Vertical pillars around the margin give the internal periphery a scalloped appearance. The genital plates, after etching with acid, appear to be fused into a blunt-pointed star having a small central madreporite and four perforations.

PERONELLA ACUÑAI (Lambert)
Plate 22, figures 7, 8

Jacksonaster acunae LAMBERT in SANCHEZ ROIG, 1926, Cuba, Dirección de montes y minas, Bol. minas no. 10, p. 59, pl. 13, figs. 6, 7.
Jacksonaster acunae nuevitasensis LAMBERT in SANCHEZ ROIG, 1926, *idem*, p. 60, pl. 13, fig. 9.
Jacksonaster acunai Roig. WEISBORD, 1934, Bull. Am. Paleontology, vol. 20, no. 70–C, p. 207 (43), pl. 22 (3), fig. 14; pl. 23 (4), figs. 1–4.

This species, originally from Loma de Calisto, Nuevitas, Camagüey, Cuba, is represented in the collection from Panama by many well-preserved individuals. It has four genital pores set about even with the inner ends of the petals. The genital plates, which are thoroughly fused, form a star with blunt points projecting between the petals. The star is visible only when deeply etched. The petals are nearly straight but expand somewhat near the outer end. They are open at the inner ends but nearly closed at the outer ends.

"Jacksonaster" acuñai differs from *Peronella peronii* (Agassiz), genotype of *Peronella*, chiefly in its swollen margin, its straight petals, and in the location of its genital pores which lie much nearer the center than those of *P. peronii*. These differences do not seem to be of generic rank. *Echinarachnius conchatus* MacClelland, the genotype of *Jacksonaster* Lambert 1914, is said to have five genital pores.

SCHIZASTER ARMIGER Clark
Plate 22, figures 1–4

A sea urchin. HARRIS, 1894, Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 172, pl. 6, fig. 11.
Schizaster armiger CLARK in CLARK and TWITCHELL, 1915, U. S. Geol. Survey Mon. 54, p. 152, pl. 70, figs. 1a–d.
Schizaster floridanus CLARK in CLARK and TWITCHELL, 1915, *idem*, p. 175, pl. 82, figs. 1a–c.
Schizaster armiger Clark. COOKE, 1942, Jour. Paleontology, vol. 16, no. 1, p. 39.

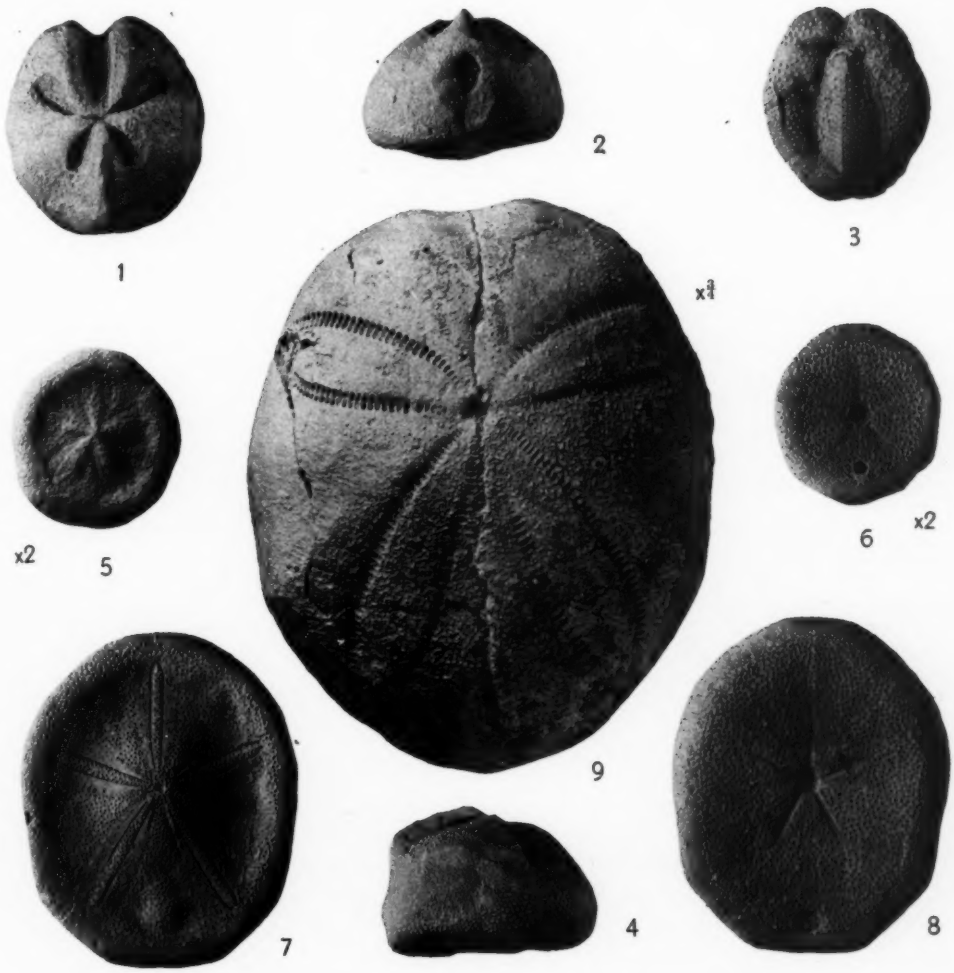
This well-known American species is represented in the collection from Panama by nine individuals, all of which are smaller than the type though well within the range in size of *Schizaster armiger*. The species is abundant at the horizon of *Basilosaurus cetoides* (Owen) in the Jackson group in Alabama and in the Ocala limestone in Florida.

EUPATAGUS CLEVEI (Cotteau)
Plate 22, figure 9

Euspatangus clevei COTTEAU, 1875, K. svenska vetensk.-akad. Handl., Bd. 13, no. 6, p. 44, pl. 8, figs. 1–4.
Euspatangus grandiflorus COTTEAU, 1875, *idem*, p. 45, pl. 8, figs. 5, 6.
Eupatagus clevei (Cotteau). GUPPY, 1882, Sci. Assoc. Trinidad Proc., pt. 12, p. 199.
Eupatagus grandiflorus (Cotteau). JACKSON, 1922, Carnegie Inst. Washington Pub. 306, p. 89, pl. 15, figs. 5, 6.

EXPLANATION OF PLATE 22

FIGS. *1–4—Schizaster armiger* Clark. *1, 2, 4*, USNM 560192; *3*, USNM 560193; ×1. (p. 92)
5, 6—Peronella dalli (Twitchell). USNM 560194, 560195, ×2. (p. 91)
7, 8—Peronella acuñai (Lambert). USNM 560196, ×1. (p. 92)
9—Eupatagus clevei (Cotteau). USNM 560197, ×¾. (p. 92)
All from USGS 16889, Madden Airfield, Panama. Photographs by Nelson W. Shupe.



Cooke, Eocene Echinoids from Panama

Eupatagus grandiflorus (Cotteau). MOLENGRAAFF 1929, Geologie en Geohydrologie het Eiland Curaçao, p. 72, pl. 24, figs. 1, 2; pl. 25, fig. 1.
Eupatagus clevei (Cotteau), Jackson, 1922, Carnegie Inst. Washington Pub. 306, p. 90, pl. 16, figs. 1, 2.

As was pointed out by Guppy (1882, p. 199), *Eupatagus grandiflorus* is a synonym of *E. clevei*, which has page precedence. The type of *E. clevei* is smaller and better preserved than that of *E. grandiflorus*, which is broken, deformed, and has somewhat wider poriferous zones. Both types are from the Eocene St. Bartholomew limestone of the British West Indies.

A fine specimen (USNM 104175) measuring 90 mm. long, 78 mm. wide, and 52 mm. high was found in 1945 by Alfred G. Fischer in the basal part of the Ocala limestone on Withlacoochee River 1 mile below the power plant at Inglis, Levy County, Florida.

This species is represented in the collection from Panama by one entire and two crushed specimens and by one fragment.

REFERENCES

ARNOLD, B. W., and CLARK, H. L., 1927, Jamaican fossil echini: Harvard College, Mus. Comp. Zoology Mem., vol. 50, no. 1, p. 28, pl. 4, figs. 6–8.

CLARK, W. B., and TWITCHELL, M. W., 1915, The Mesozoic and Cenozoic Echinodermata of the United States: U. S. Geol. Survey Mon. 54.

COLE, W. S., and PONTON, G. M., 1932, Variations of *Laganum dalli* Twitchell: Am. Jour. Sci., ser. 5, vol. 24, pp. 23–27, 1 fig.

COOKE, C. WYTHE, 1942, Cenozoic irregular echinoids of eastern United States: Jour. Paleontology, vol. 16, no. 1, pp. 1–62, pls. 1–8.

CORYELL, H. N., and EMBICH, J. R., 1937, The Tranquilla shale (upper Eocene) of Panama and its foraminiferal fauna: Jour. Paleontology, vol. 11, no. 4, pp. 289–305, pls. 41–43, 1 fig.

COTTEAU, G., 1875, Description des échinides tertiaries des îles St. Barthelemy et Anguilla: K. svenska vetensk.-akad. Handl., Bd. 13, no. 6, 47 pp., 8 pls.

GUPPY, R. J. L., 1882, On the fossil Echinodermata of the Westindies (abstract): Sci. Assoc. Trinidad Proc., pt. 12, pp. 193–199.

HARRIS, G. D., 1894, The Tertiary geology of southern Arkansas: Arkansas Geol. Survey Ann. Report for 1892, 207 pp.

LAMBERT, JULES, 1931, Note sur le groupe des *Oligopygus*, la nouvelle famille des Haimeidae, et sur quelques échinides fossiles de Cuba: Soc. géol. France Bull., sér. 5, t. 1, p. 292.

——, and THIÉRY, P., 1909–1925, Essai de nomenclature raisonnée des échinides, 607 pp. 15 pls.

OLSSON, A. A., 1942, Tertiary deposits of northwestern South America and Panama: Eighth Am. Sci. Congr. Washington, D. C., 1940, Proc., vol. 4, p. 236.

SANCHEZ ROIG, MARIO, 1926, Contribución a la paleontologia cubana "Los equinodermos fósiles de Cuba": Cuba, Dirección de montes y minas, Bol. minas, no. 10, 143 pp., 43 pls.

VAUGHAN, T. W., 1926, The stratigraphic horizon of the beds containing *Lepidocyclina chaperi* on Haut Chagres, Panama: Nat. Acad. Sci. Proc., vol. 12, no. 8, pp. 519–522.

WEISBORD, N. E., 1934, Some Cretaceous and Tertiary echinoids from Cuba: Bull. Am. Paleontology, vol. 20, no. 70-C, 84 pp., 9 pls.

PUBLISHED BY PERMISSION OF THE DIRECTOR, U. S. GEOLOGICAL SURVEY. RECEIVED JULY 12, 1947

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 94–100, PL. 23, 2 TEXT-FIGS., JANUARY 1948

HALOSAURIDAE FROM THE CALIFORNIA TERTIARY

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ABSTRACT—While the Halosauridae are not represented in the living marine fish fauna of California, the family is fairly commonly found as fossils in Tertiary deposits. A Cretaceous form is little known and may have lived during upper Moreno time. At least two Tertiary types are identified by scales. The Halosauridae of the California Tertiary occur commonly only in deep sea deposits and would normally be found in abyssal accumulations. Climatic changes appear to have caused their extinction along the California coast.

INTRODUCTION

HALOSAURIDAE are not represented in the living marine fish fauna of California, but occur fairly commonly as fossils in Tertiary deposits of the region. This peculiar group of eel-shaped fishes with long pointed snouts is definitely restricted to the deep sea, and appears to frequent only the deeper waters of tropical to semitropical oceans. Cooling of the ocean very likely caused extinction of the group in California in Pliocene times.

Scales of Halosauridae are common in some California and Oregon beds of Oligocene, Miocene and Pliocene age. The several scale occurrences are enumerated below. As yet, skeletal remains of only two individuals are known. A complete skeleton was described (David, 1943) as *Laytonia californica*. A second specimen showing the head of a much larger fish, evidently of the same genus was found by Dr. A. J. Ousdal in the San Marcos Pass area, Santa Barbara County. Structural details of the skull, clearly discernible in the latter specimen, when compared with those of the individual described previously verify the taxonomic position of the genus. Description of this specimen and a record of the known occurrences of halosaurid scales in California are given below.

We have to thank Dr. A. J. Ousdal and the Department of Geology, University of Southern California, for their generosity in presenting fossil fish material to the California Institute of Technology. The author wishes also to express her appreciation to Dr. Chester Stock for his interest in this paper and for the facilities made available by the Division of Geological Sciences, California Institute of Technology. The photographs of fish scales were taken by Mr. J. Smith of South Pasadena.

DESCRIPTION OF MATERIAL

LAYTONIA cf. CALIFORNICA David
Text fig. 1

Type scale.—No. 10400, Calif. Inst. Tech. Vert. Paleont. Coll., 3.5 mm. long by 2 mm. deep.

Type locality.—The Union Oil Company well Stearns No. 75 at a depth of 4425 to 4435 feet, uppermost Miocene, Delmontian age. The location of the well is in Sec. 7, T. 3 S., R. 9 W., Brea Olinda Oil Field, Orange County, California.

Additional occurrences.—(1) Texas Oil Company well, Fernando No. 1, at intervals from 5615 to 5625 ft., 5728 to 5738 ft., and 5864 to 5874 ft. depth, in strata of uppermost Miocene, Delmontian age. Location of well, Sec. 11, T. 4 N., R. 17 W., Hasley Canyon, Ventura County, California. (2) Texas Oil Company well, Towle No. 1, from 4758 to 4762 ft. in depth, in lowermost Pliocene strata. The location of well is in Sec. 3, T. 3 N., R. 17 W., in Hasley Canyon. (3) General Petroleum Company well, Heath No. 1, from 9806 to 9821 ft. Location of well is in Sec. 34, T. 3 S., R. 11 W., Buena Park Field, Los Angeles County, in Repetto formation. (4) Texas Oil Company well, Spencer No. 1, Sec. 1, T. 4 S., R. 11 W., Buena Park, Los Angeles County, from 8872 to 8882 ft. in depth in the Repetto.

Description.—Several complete scales from lateral side of body, small and slender,

measuring 3.9 by 2.5; 3 by 1.9 millimeters, length to depth. Some fragments indicate larger scales, and one of these evidently from the extremity of the body is deeper than long. Basal portion of scales with four to six sharply cut folds, continuous to nucleus; nucleus more or less enlarged, depending upon extent of regeneration of scale. Basal border deeply scalloped by protruding folds which end in sharp-angled points. Dorsal and ventral sectors of scale with strong straight circuli, about 10 circuli in $\frac{1}{3}$ of a millimeter distance. Central basal folds divided by much finer transverse circuli, 11 in $\frac{1}{2}$ millimeter distance; the central circuli directed diagonally toward each other, meeting in sharp angles in the three central folds, parallel to the sharp angled basal border. Nucleus very characteristically shaped as in related living genera (see Halosaurus, Plate 23, figure 1). Nuclear area usually ovoid or eggshaped with smaller end toward apical pole; nuclear parts of scale not reached by basal folds, ornamented by fine tuberculi; nucleus dorsally and ventrally with five to six half crescent-shaped circuli-like structures surrounding the nucleus with strong curved lines. Very fine apical lines radiating from nucleus and particularly well defined at apical pole of scale. Deep scales from other parts of body are probably also present, but are too fragmentary to be described.

LAYTONIA? ZEMORRENSIS David n. sp.
Plate 23, figure 2

DAVID, 1944, p. 32, Plate III, figure 23.

Type scale.—No. 10401, Calif. Inst. Tech. Vert. Paleont. Coll., 3.8 mm. long by 3.5 mm. deep (1944, Plate III, figure 23).

Type locality.—From Texas Company well, Pioneer Unit Plan No. 1, Sec. 33, T. 11 N., R. 23 W., San Bernardino Baseline and Meridian, in the southern Sunset district, San Joaquin Valley, California, from 6228 to 6292 ft. in depth; lower Zemorrian age.

Additional occurrences.—Scales of this type occur in (1) Texas Company well Pioneer Unit Plan No. 1 from 5454 to 7304 ft. in depth in the middle to lower Zemorrian, and in well No. 2 from 10,480 to 10,498 ft., of lower Zemorrian age. (2) The Ohio Oil Company well M and M No. 1, at 5735 ft. depth, lower Zemorrian. This well is situated in Sec. 32, T. 30 S., R. 22 E, Mt. Diablo Baseline and Meridian, McKittrick District, Kern County. (3) In the Richfield Oil Company well Temblor Hills, Unit 1-1 from 6327 ft. to 6332 ft. in depth in the lower Zemorrian. The location of well is in Sec. 35,

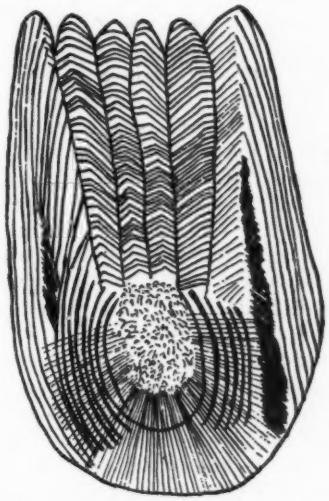

FIG. 1—*Laytonia* cf. *californica*. Scale, type specimen No. 10400 Calif. Inst. Tech. Vert. Paleont. Coll., from Union Oil Company well, Stearns No. 75, at depth from 4425 to 4435 ft.; approx. 20.

T. 31 S., R. 21 E., Mt. Diablo Baseline and Meridian, West Midway area, San Luis Obispo County. (4) Scales possibly of the same species were found in the Lower Bassendorf shale near Coos Bay in southern Oregon. These outcrops are of Oligocene (lowermost Refugian) age.

Description.—Medium sized scales, majority elongate: 6 by 3.7, 5.2 by 4.5, 5 by 4.1, 5 by 3.5, 5.1 by 2.7, 4.2 by 2.5, 3.8 by 3.1, 3.1 by 3 millimeters, length by depth. Some scales are wide: 4.1 by 4.9, 4.1 by 4.8, 4.1 by 4.6 millimeters, length by depth. Elongate scales with five to eight or nine sharply cut basal folds in basal portion, continuous to nucleus in most scales (figure 23, Plate III, David, 1944); regenerated scales with smooth area surrounding enlarged nucleus are rare. Basal folds slightly protruding beyond basal border, their protruding ends evenly rounded; basal border often diagonal, higher

toward dorsal or ventral border. Dorsal and ventral sectors of scale with strong straight circuli about 20 in 1 mm. distance; these much coarser in regenerated scales with 16 to 17 in 1 mm. distance near apical ventral border; a larger number sometimes occurs.

Central basal folds divided by transverse circuli, which are not much finer than vertical ones, about 20 in 1 mm. distance. Transverse circuli more or less evenly rounded in elongate scales and parallel to their basal border, angled at least in some of the wider scales. Nucleus as in scales of related forms (*Halosaurus*, Plate 23, figure 1), small ovoid or eggshaped with six or seven strengthened and coarse circuli surrounding its apical portion in curved lines. Very fine apical structures radiating from nucleus and crossing circuli. Wider or deeper scales often regenerated (Plate 23, figure 2) with enlarged smooth area surrounding nucleus, coarse vertical circuli in apical portion, these becoming finer toward basal border, coarseness of circuli varying according to degree of regeneration. Transverse circuli dividing basal folds are angled at least in the most apical portion of scale, and there separated from each other, five to six in 0.4 mm. Circuli near basal border rounded and more crowded. Large nucleus of scale figured in Plate 23, figure 2 surrounded by coarse and strengthened circuli and showing typical apical structure of fine radiating lines.

Relationships of species.—The type specimen of *Laytonia californica*, No. 10227 Calif. Inst. Tech. Vert. Paleont. Coll., is covered with scales; these are of about the same size and general structure as the scales described above as *Laytonia* cf. *californica*. The scales on the specimen overlap each other. Not all the structural details can be discerned, but there is every indication that the scales found in the well cores represent the same species as *Laytonia californica* from the lower Modelo of the Santa Monica Mountains. The small scales show very characteristically the halosaurid structure with typical large, ovoid, smooth nucleus surrounded by strong curved circuli and with fine radiating apical lines, the strong straight circuli in dorsal and ventral sectors, and sharp central basal folds. There can be no doubt that the fossil scales belong to the Halosauridae, and to a genus nearly related to living forms. It is characterized by comparatively few central folds, which are pointed at their basal ends, protruding considerably beyond the basal border; the transverse circuli that divide the central folds are also acutely angular. The Recent *Halosaurus* scale (Plate 23, figure 1) has circuli and basal ends of the central folds evenly rounded. The folds are more numerous than in the fossil scale, and the basal border is more or less straight. Other genera, as for instance *Halosaurichthys*, have central folds and transverse circuli much more acutely pointed than the fossil; the Recent form differs likewise in the irregular outline of its scales with central part of scale protruding beyond dorsal and ventral parts, or with its contour angled in various ways. The scale of *L.* cf. *californica* can therefore not be identified with any one of the living genera, even though it is nearly related. There is no similarity to scales of the Nothacantidae, a family that is thought to be related to the Halosauridae. The small scales of the Nothacantidae show an entirely different structure. The fossil skeleton with which *Laytonia* cf. *californica* is tentatively identified also shows definite differences from living genera.

The type of scale referred to *Laytonia* cf. *californica* is found in the uppermost Miocene (Delmontian) and in the lower Pliocene (Repetto, lower Pico). The skeleton occurred in the upper Miocene (lower Mohnian), slightly lower in the section than the strata containing the scales. Skeletal re-

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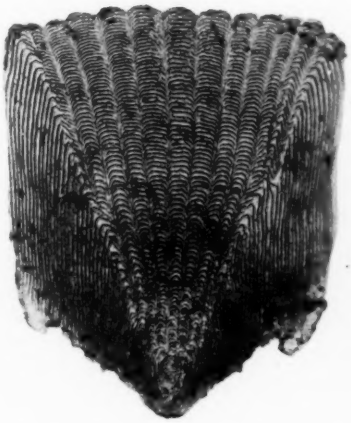
EXPLANATION OF PLATE 23

FIG. *1*—*Halosaurus oweni* Johnson. Lateral scale from fish caught off Cape May, New Jersey, and collected by S. S. *Albatross;* ×12¾.

2—*Laytonia zemorrensis* n. sp. Scale from Texas Company well, Pioneer Unit Plan, at depth from 10480 to 10498 ft.; ×19.

3—*Laytonia* cf. *californica*. Skull, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., from near summit of San Marcos Pass, Santa Barbara County; ×1¾.



1

2

3

David, California Tertiary Halosauridae

mains of the species are rare in the deposits that accumulated during lower Mohnian time. If the skeleton and scales represent the same species, *L. californica* ranges through the upper Miocene to the lower Pliocene. The second species described above, *Laytonia? zemorrensis*, occurs with considerably larger scales. Its general structure is very similar to that of *L.* cf. *californica* and shows the characters of the family Halosauridae to which it undoubtedly belongs. This species, however, has more evenly rounded transverse circuli, the basal ends of the central circuli are not evenly rounded as in Recent scales. *L.? zemorrensis* is abundant in the lower Miocene or Oligocene (Zemorrian) shales of the southern San Joaquin Valley. An underlying similarity in structure to *L.* cf. *californica* suggests that both forms may represent the same genus.

Skeletal Material of LAYTONIA cf. CALIFORNICA David

Plate 23, figure 3, text figures 2 *a*, *b*

A head only, No. 10399 Calif. Inst. Vert. Paleont. Coll. was found at Calif. Inst. Tech.

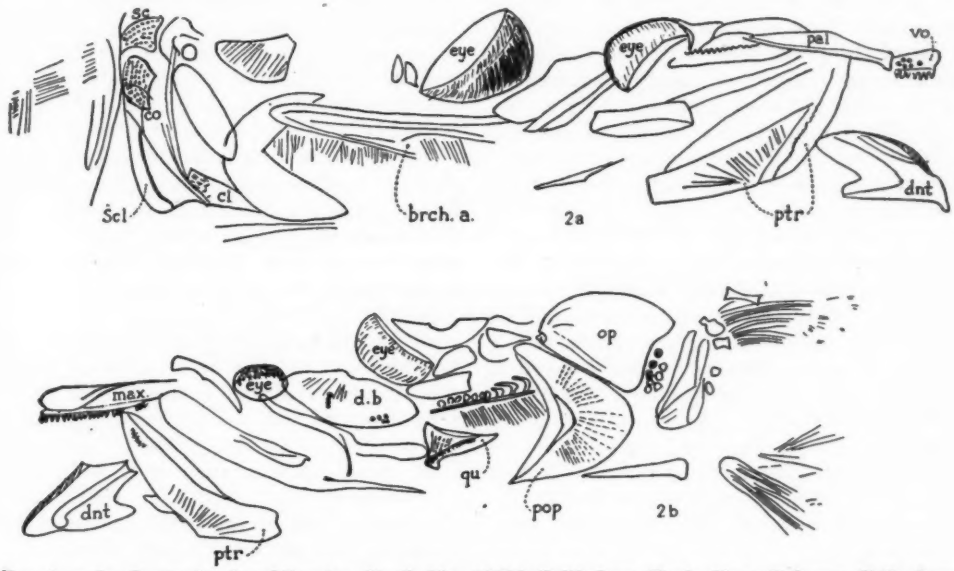


FIG. 2, *a*, *b*—*Laytonia* cf. *californica*. Skull, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., from near summit of San Marcos Pass, Santa Barbara County; ×1⅔. *a*, left side of skull; *b*, right side of skull.

Abbr. Brch. a—branchial arches
cl. —clavicula
d.b. —dermal bone
dnt. —dentary
op. —opercular
max. —maxilla
pal. —palatine
pop.—preopercular
ptr. —pterygoid
qu. —quadrate
scl. —superclavicular
sc. —scapula

folds are rounded and the basal border is straight and slightly scalloped. In these characters the form may resemble *Halosaurus* more closely. The average number of folds in *L.? zemorrensis* is larger than in *L.* cf. *californica*, but the folds are by no means so numerous as in Recent *Halosaurus*. The basal border of the fossil scale often has a diagonal position, and the dorsal border is higher than the ventral border. Transverse

loc. 391 in the San Marcos Pass area, Sec. 10, T. 5 N., R. 32 W, near summit in strata of Miocene age, Lompoc Quadrangle. Measurements: the head measures 73.5 mm. in length and 20.8 mm. in depth in the opercular region. The snout is 36 mm. long and approximately 13 mm. deep. The large eyeball measures 9.5 mm. in diameter. The opercular arch is plainly visible in the specimen. The opercular is large, being 14.5 mm.

long and 10.5 mm. deep. As in specimen No. 10227 (David, 1943, Plate II, figure 1) this element is articulated very high and near the top of the skull; its upper border is rounded, the lower one is slightly concave and the posterior border is curved in its lower half where it lies along the cheek. The latter is covered by small round scales. The opercular in specimen No. 10227 appears to be turned upside down.

The right preopercular is in place; the left one is preserved and lies beneath the lower border of the head; it is crescent-shaped. The bone is 16 mm. deep, while the diameter of its upper limb is 14 mm. and that of the lower limb 16.5 mm. Opercular and preopercular are highly ornamented with tubercles and radiating ridges. No subopercular is visible. Both eyeballs are conspicuous and protrude above level of surrounding bones; the right eye is more completely preserved than the left and pushed slightly behind the latter, 9.5 mm. in diameter. The large bone underlying the eye is probably a dermal bone. The main portion of the snout is occupied by a pair of large diagonally placed bones, similar to the strong elements preserved in same position in front of the eyes in specimen No. 10227. These undoubtedly represent the pterygoids (ecto-entopterygoids) and may consist of several bones; the left one in front is well preserved, showing radiating ridges in its lower part and evidently a row of teeth anteriorly.

Of the mandibular suspensorium the triangular quadrate may be recognized, lying in front of the long and slender branchial arches. The bones forming the gape of the mouth enrich our knowledge of the genus insofar as the lower jaw is concerned. It is a strong triangular bone strengthened by a central diagonal ridge. There is a large circular indentation at its posterior base; the bone also becomes slender at its posterior upper border. The teeth seem to be lost, but the anterior part of the dentary shows a border of bone with diagonally placed rod-like structures partly overlying each other. The anterior end of the bone evidently points downward to some degree as in *Notacanthus*. In the type specimen of the genus, No. 10227, the dentary is evidently present; it is pushed upward above the end of the parasphenoid, and was not recognized in the description, but is visible on Plate II, figure 1 as an unnamed strong pointed prolongation of the parasphenoid. The tip of the upper jaw is formed by a clearly visible bone, ornamented by a pattern of tubercles; this evidently is the rostrum or vomer. Eight strong teeth are visible at its lower border; these may form part of a different bone (intermaxillary?) underlying the rostrum. A slender toothed bone in back of the rostrum may be the palatine. It is ornamented by transverse ridges. A mass of tuberculated bones continue rostrum and palatine posteriorly and centrally, but individual elements can not be identified. The large elongate bone in front of the right eyeball evidently represents one of a series of dermal bones. It is 13 mm. long and 4.5 mm. deep.

The pectoral arch is feeble and not very clearly marked; two small tuberculated bones visible on the left slab may be coracoid and scapula; a rounded elongate, vertically placed bone is better marked and appears to be the superclavicle or clavicle; a triangular bone near the ventral side of the body extending below the preopercular may be the clavicle. The right pectoral fin is clearly preserved and, as in the type specimen, is placed high toward the dorsal side of the body; 14 rays are present; some more may have been lost; their ends are broken off. Dismembered finrays are visible near the ventral end of the head, and some of these may be parts of the left pectoral fin. However, if they belong to the ventral fins, they are now definitely out of place.

REMARKS

Ample evidence has been found to prove the existence of halosaurid fishes in the California Tertiary, even though these forms are not present in the Pacific ocean off California today. Several species must have existed, but no detailed information is available as yet concerning the characters which delimit species in this group as well as the vertical range of specific types. A species of Halosauridae, *Echidnocephalus? pacificus*, was described by Cockerell (1919, p. 185, pl. 34, fig. 11) from the upper part of the Moreno formation (Cretaceous) of the Panoche Hills. Very little is known about this form since it was described on the basis

of a single scale. The description and figure give no details. Insofar as can be judged by figure 11 in Cockerell's paper, the outline of the scale is much more rounded than that in any of the scales found in the Tertiary.

Two halosaurid scales have been described above. *Laytonia? zemorrensis* occurs quite commonly in shaly deposits of the lowermost Miocene or Oligocene of the southern San Joaquin Valley. Other specimens found commonly with the halosaurid scales in the same deposit are of the Macrouridae, Myctophoidea and Berycomorphi. Only occasionally do scales of the Clupeoidea occur. The deposits must have accumulated to a great extent in an abyssal sea, the natural environment of the living Halosauridae. The lower Miocene or Oligocene halosaurid scale is large and well defined. It has been only tentatively assigned to the genus *Laytonia*. The genus has been described from the upper Miocene and scales similar to those covering the skeleton of that genus have been found in strata of that epoch. The lower Miocene scales are not fundamentally different, and it seems that both represent the same genus.

Up to the present time no Halosauridae have been found in the middle Miocene. Nearly all known Californian deposits of this stage accumulated in shallower seas than those in which Halosauridae would normally be found. In the upper Miocene a halosaurid scale occurs that differs specifically from the one in the lower Miocene or Oligocene. This has been described under the name *Laytonia* cf. *californica*. It occurs in silty deposits of uppermost Miocene (Delmontian) and lowermost Pliocene age of the Los Angeles and Ventura Basins. It is found occasionally in oil well cores and not more than one scale is usually found in any one well. In the deposits with *Laytonia* cf. *californica* fish remains are in general rare and are represented by bone fragments, teeth and scales belonging to the Macrouroidea and to *Lampanyctus*. Additional forms are occasionally encountered. These deposits are evidently also deep sea accumulations, but of different character than those mentioned above from the lower Miocene or Oligocene. *L.* cf. *californica* ranges upward into the lower Pliocene.

Skeletal remains of fish are not usually preserved in the California Tertiary, except in certain deposits which range in age from upper middle Miocene to upper Miocene. Various fish faunas of that age have been described (Jordan; Jordan and Gilbert, 1907 to 1927; and David, 1943); none of these is of abyssal character. Halosaurid fish are therefore very rarely found, and evidently exist here in deposits which did not accumulate in their normal habitat. The possibility of preservation of their scales in these neritic deposits is even more remote. Only one complete skeleton of the Miocene Halosauridae is known. This is *Laytonia californica*, described from the lower Modelo (lower upper Miocene) of the Santa Monica Mountains, Los Angeles County. The scale described as coming from the uppermost Miocene to lower Pliocene belongs evidently to the same species or a nearly related one. So far, scales have not been found in deposits of same age as those in which the skeleton was entombed presumably because the ecological conditions during the time of accumulation of these strata did not favor the presence of abyssal forms.

A second skeletal specimen, No. 10399 Calif. Inst. Tech. Vert. Paleont. Coll., shows only the head. It was found in the San Marcos Pass area, near the summit of the pass. The specimen, described above, shows a head considerably larger than the one in the type specimen of *Laytonia californica*. The skull characters of both specimens agree and show similarities to those of the Halosauridae, although no special relationship is shown to any known recent form.

The fossil and living forms differ in the opercular bones. The preopercular is well formed in *Laytonia*, indicating a primitive character in comparison with the degenerated type of preopercular in modern forms. There are differences in the structure of the mouth, shown mainly by the shorter and differently constructed lower jaw. The eye of the fossil genus appears likewise to have been larger compared with the size of the head than in modern forms. Differences in the structure of the dermal bones and mandibular suspensorium, insofar as the bones can be determined in the fossils, are probably of less importance. The two fossil specimens conform well in their structure and represent very likely the same genus. It is

not possible to determine whether the two are specifically identical since specific differences are not usually seen in skull characters. However, the distinctly larger size of No. 10399 may indicate a different species. The exact age of specimen No. 10399 is not known, but considering the general locality whence it comes, it is likely to be upper Miocene.

CONCLUSIONS

The following conclusions concerning the fossil Halosauridae from California seem to be justified. A Cretaceous form is little known and may have lived during upper Moreno time. At least two types lived in the Tertiary as identified by their scales. *Laytonia zemorrensis* existed during the lower Miocene or Oligocene (Zemorrian), and the upper limit of its range may be later, since no members of the Holosauridae are found in strata of middle Miocene age. *Laytonia* cf. *californica* ranges from the uppermost Miocene to the lower Pliocene. If the fossil scale and the skeleton, described as *Laytonia californica*, belong to the same species, the latter species has a range to the lower upper Miocene (lower Mohnian). The Halosauridae of the Californian Tertiary occur commonly only in deep sea deposits, and would normally be expected in abyssal accumulations. No Halosauridae exist off the California coast today. Climatic changes seem to furnish the most likely cause of their extinction, since Recent American Halosauridae are restricted to the warmer regions of Central America.

MANUSCRIPT RECEIVED JUNE 3, 1947.

REFERENCES

COCKERELL, T. D. A., 1919, Some American Cretaceous fish scales with notes on the classification and distribution of Cretaceous fishes: U. S. Geol. Surv., Prof. Pap. 120, pp. 165–188.

DAVID, L. R., 1943, Miocene fishes of southern California, Geol. Soc. America Special Paper No. 43.

——, 1944, Use of fossil fish scales in micropaleontology: Carnegie Inst. Wash. Contrib. to Paleont., Publ. 551, pp. 25–43.

GUENTHER, A., 1887, Deep sea fishes, family Halosauridae. Report on scientific results, H.M.S. *Challenger*, Zoology vol. 22, pp. 232–242, pls. 59–60.

JORDAN, D. S., 1907, The fossil fishes of California: Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, pp. 95–144.

——, 1921, The fish fauna of the California Tertiary; Stanford Univ. Publ., Biol. Sci., vol. 1, no. 4, pp. 235–300.

——, 1924, Miocene fishes from southern California; South. Calif. Acad. Sci. Bull., vol. 23, pp. 42–50.

——, 1925, The fossil fishes of the Miocene of California: Stanford Univ. Publ., Biol. Sci., vol. 4, no. 1, pp. 1–51.

——, 1927, The fossil fishes of the Miocene of southern California: Stanford Univ. Publ., Biol. Sci., vol. 5, no. 2, pp. 88–97.

JORDAN, D. S. and GILBERT, J. Z., 1919, Fossil fishes of southern California: Stanford Univ. Publ., pp. 1–98.

——, 1920, Fossil fishes of the Diatom beds of Lompoc, California; Stanford Univ. Publ., pp. 1–45.

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 101–105, 1 TEXT-FIG., JANUARY 1948

PALEONTOLOGICAL NOTES

ACETIC ACID ETCHING TECHNIQUE APPLIED TO CAMBRIAN BRACHIOPODS

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INTRODUCTION

My discovery in the summer of 1942 that phosphatic brachiopods can be freed from carbonate matrix by the use of dilute acetic acid came about fortuitously. Dr. Virgil Barnes of the Texas Bureau of Economic Geology told me he had seen in a thin-section of Wilberns limestone what he thought might be a conodont. Remote as the possibility was, I immediately etched some Wilberns matrix in acetic acid—a well-known technique for obtaining free conodonts from limestone. No conodonts were obtained—then or later—but the residue contained numerous beautifully preserved and cleanly etched acrotretoid brachiopods.

Having in previous years devoted hundreds of hours to the laborious mechanical cleaning of similar shells under a microscope, I began testing the applicability of the acetic acid technique to other limestone samples in my Cambrian collections. The program had no more than begun when I reported for duty with the Army Air Forces in late summer, and it was not resumed until 1946 at the University of Minnesota. The technique was formally reported at the 1946 meeting of the Paleontological Society.

ETCHING PROCEDURES

The process of etching is itself simple but slow, and similar to that being used so widely today in the hydrochloric acid etching of silicified fossils. Small limestone fragments and descriptive penciled labels are placed in pyrex beakers, the fragments are covered with 80% technical grade acetic acid, and the beakers filled with water. Larger pieces of matrix are placed in stainless steel baskets suspended in battery jars. After 48 to 96 hours the exhausted solution is decanted, and if matrix remains, fresh solution is added. Addition of fresh acid to exhausted solutions is uneconomical, for the resulting reaction is very slow.

When all calcium carbonate has been digested, the finer argillaceous material is removed either by decantation during washing, or by screening through a 60-mesh sieve. Etched shells are fragile and rinsing must not be vigorous, but the buffer action of the water is such that with reasonable precautions breakage can be minimized. After thorough rinsing in several changes of water, the residue in its original beaker is placed over a radiator to dry.

Apparently varying the acid concentration and temperature does not affect the shells appreciably. My etching is conducted at room temperatures in 10–20% acid solution, without a hood to carry off fumes. Although several hundred batches of matrix have been processed during the past year in a room where metal equipment is exposed at all times, as yet I have seen no evidence of damaging corrosion; under identical conditions hydrochloric acid fumes produce visible corrosion in a week or two.

POST-ETCHING PROCEDURES

Under a binocular microscope shells are transferred from the dry residues to 28-ply micropaleontological slides by means of a moistened brush. The shells differ greatly in their state of preservation, ranging from the extreme delicacy of some translucent micrometrids and linguloids, through thicker laminated shells that flake if touched with a dry brush point, to some specimens of *Dicellomus* that might yesterday have covered living animals. The present state of preservation seems dependent upon the history of the sediment, for shells of all genera from a given residue show similar preservation.

All shells that are to be mounted for photography, handled frequently during study, or transported loose in slides, should

be hardened in some way to diminish likelihood of breakage. The methods of hardening to be described below are the result of limited experimentation, and other methods will be tried as time permits. Suggestions will be welcomed.

Valves selected for photography are mounted in slides with gum arabic. Most are not entirely clean, having clinging to them quartz, pyrite, glauconite, or clay particles that must be removed with needle and brush before impregnation with a hardening agent. A dilute solution of Alvar in alchohol is flowed on from a brush and absorbed by the shell; if slivers of Alvar crystallize on the surface—a common occurrence—they can be removed by brushing with alcohol. The impregnated shell is likely to be glossy or resinous in appearance, but photographs well when coated with ammonium chloride. Magnesium coating has proved unsatisfactory for two reasons: a uniformly thin coating is difficult to achieve, and removal of the coating—which of necessity must be a mechanical process—invites damage to the shell.

The method I have used for impregnating loose shells is exasperating and slow. A shell is placed on a watch glass, covered with a drop of Alvar in alcohol, and if manipulated deftly with a brush, when dry will not be cemented either to glass or brush.

COMPOSITION AND OCCURRENCE

Etched fragments of *Dicellomus* from the Pilgrim of Montana, *Linnarssonella* from the Wilberns of Texas, and an acrotretoid from the Cap Mountain of Texas have been X-rayed by Dr. J. W. Gruner and Mr. Lynn Gardiner at the University of Minnesota. The resulting patterns show the shell material to consist of hydroxy apatite, a composition essentially identical to that of condodonts. A detailed study of shell composition is planned.

To date phosphatic brachiopod shells have been obtained by etching from the Lower Cambrian of Nevada, Alberta and British Columbia; the Middle Cambrian of Utah, Idaho, Alberta, British Columbia, Montana and Wyoming; and the Upper Cambrian of Montana, Wyoming, South Dakota, Missouri, Oklahoma, Texas and Pennsylvania.

In addition to brachiopod shells a wide variety of other organic remains have been found in residues: sponge spicules, hyolithids, gastropods (both as glauconite steinkerns and silicified conchs), barnacles? (*Kinsabia* Lochman 1940), holothuroid? plates, trilobites (silicified and as clay? casts), receptaculitids?, and diverse problematica.

A SIMPLE DEVICE FOR COATING FOSSILS WITH AMMONIUM CHLORIDE

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It is now generally recognized that the application of a white coating to fossils is an essential for photographic reproduction in order to eliminate spottiness and to bring out fine structural details otherwise lost on a dark background. It is usual for this purpose to cover the surface of the specimens with a fine film of ammonium chloride and several methods have been described by which this can be done. The first, and for many years the most widely used, is the one originally recommended by Grabau and Shimer in 1910. This involves the use of flasks filled with ammonia and hydrochloric acid, as illustrated by the well-known diagram published by Ulrich and Bassler in 1923. This technique has found its way into textbooks published as far afield as Germany and Australia. Some years ago the writer, assisted by his wife, developed an easy, quick and efficient method of whitening fossils which may be of interest to other

workers. The apparatus used is a simpler version of the type described by Cooper (1935, p. 357).

The requirements are a glass tube about six inches in length, with a bulb near one end, and a rubber bulb with a short length of rubber tubing attached.

The glass tube, preferably of pyrex glass, should have an internal diameter of a little more than one-fourth inch; the bulb may be blown to a diameter of about one and one-half inches. It should not be more than one-half inch from one end of the tube and this end should be slightly constricted, but the internal diameter of the tube at the tip should not be reduced to less than one-eighth inch.

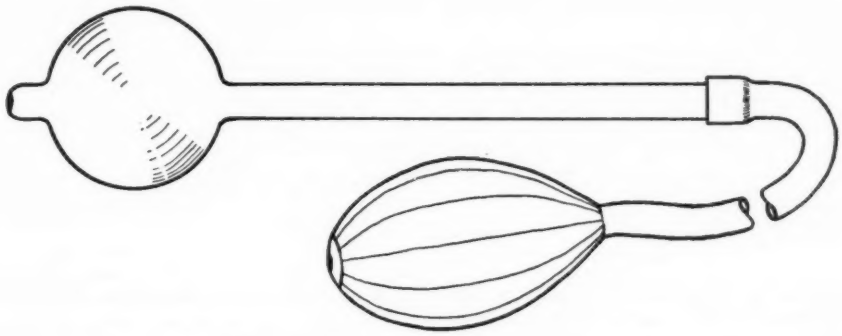

FIG. *1*—Sublimate apparatus, about ⅔×.

The exact length of the glass tube on the other side of the bulb is not important; about four inches will be found sufficient and convenient.

The second piece of equipment is a rubber bulb with internal valves so that air may be drawn in through one end and expressed through the other. The latter end should be firmly attached to a piece of rubber tubing, several inches long and wide enough to slip over the end of the glass tube. Bulbs of this type, with a suitable length of rubber tubing are used in connection with various types of atomizers (inhalers) and are obtainable from surgical supply stores.

Fine, dry ammonium chloride powder is now filled into the glass bulb through the long end of the glass tube until the bulb is about half full. The rubber tube is then attached to the long end of the glass tube and the glass bulb is heated over a flame. In less than a minute ammonium chloride vapours begin to escape through the mouth of the tube which may now be directed towards the specimen to be coated with white. The ammonium chloride vapours are forced out of the glass bulb in a series of small puffs by pressing the rubber bulb in the same way as one would use an atomizer. One heating of the bulb is usually enough to apply the coat to one fairly large or several small specimens. Very hot vapour gives a thick and very white coat which is not always desirable, cooler vapours being necessary to supply the thin and very fine-grained films required for specimens which it is intended to illustrate on a magnified scale.

During the first heating the ammonium chloride powder in the glass bulb changes into a crystalline aggregate which cannot fall out of the bulb. One filling is sufficient for many dozens of applications. In heating the glass bulb, it is desirable to use a broad flame so that the short mouth piece in front of the bulb is also thoroughly heated. In this way sublimation of ammonium chloride near the end of the tube is prevented. If the end of the tube is too cold, a deposit of ammonium chloride will gradually be formed which clogs the tube mouth. It is then necessary to heat the end of the tube until the ammonium chloride deposit has evaporated or at least is so reduced in size that it can be blown out.

It will be realized that ordinary rubber bulbs without valve action, such as powder sprays, are useless, because they draw the

ammonium chloride vapour back through the long end of the glass tube into the rubber tube and rubber bulb which would soon be filled up with sublimate.

The writer's thanks are due to Mr. W. J. Parr of the Mines Department, Melbourne, who encouraged him to write this note, and gave valuable assistance in the completion of the mansucript.

MANUSCRIPT RECEIVED FEBRUARY 1, 1947.

REFERENCES

COOPER, C. L., 1935, Ammonium chloride sublimate apparatus: Jour. Paleontology, vol. 9, pp. 357–359.

GRABAU, A. W., and SHIMER, H. W., 1910, North American Index Fossils. Vol. 2, pp. 818–819.

ULRICH, E. O., and BASSLER, R. S., 1923, Paleozoic Ostracoda: their morphology, classification and occurrence: Maryland Geol. Surv., Silurian, pp. 281–283.

MONOPHYLETIC OR POLYPHYLETIC DERIVATION OF AMMONITES?

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Dr. Ir. E. C. N. van Hoepen, M. I., (1946) devotes all of the fifth part of his monograph on keeled ammonites of the South African Gault(10 quarto pages) to an attempt to refute some earlier remarks of mine (Haas, 1942, pp. 144–145), in particular my sentence: "The trend prevailing in modern ammonitology is . . . that toward polyphyletic, not monophyletic, derivation of families and, as repeatedly shown above, even of genera."

However—at least as far as families are concerned—repeated utterances by Dr. L. F. Spath, as summarized 1938 (p. 14) for "all our ammonite families," support the above sentence. Dr. van Hoepen states that, as far as he knows, Spath "has not clearly defined" his views on this subject "anywhere," adding: "if he did do so, I am sorry to have missed it." However, Spath's above utterance is quoted in my paper (1942, p. 143), just a page ahead of the remarks disapproved by van Hoepen.

Also my above statement does not speak of polyphyletic *origin*, but, quite intentionally, of polyphyletic *derivation*. Whereas the former term implies, objectively, relationship, the latter tacitly admits that it "takes care of the taxonomic problem only" without implying a truly phylogenetic meaning (Haas and Simpson, 1946, p. 342).[1]

Some more obvious misunderstandings and other remarks of van Hoepen's cannot be left unanswered:

(1) He is mistaken in calling von Pia and Schindewolf my masters. The former was my university colleague, the latter quoted me, in the very paper now so frequently cited by van Hoepen (1927, p. 159), many years before I ever had an opportunity to quote him.

(2) Characterization of the ribs of *Elobiceras* as "single, straight, club-shaped, . . . widening towards the periphery" (Haas, 1942, p. 98) is a quotation from Spath, a fact not clearly recognizable from van Hoepen's rendition.

(3) My statement that "another group of *Elobiceras* than the fourth . . . was superfluously raised to the rank of an independent genus, '*Rhytidoceras*,' by van Hoepen . . ." should dispose of his question if *Rhytidoceras* is referred by me to group four or to a new group.

(4) Careful comparison of my remarks on *Elobiceras irregulare* with Spath's (1922,

[1] Here it might be added to van Hoepen's (1946, p. 262) statement "that a son can only have one father" that he has got to have a mother, too.

pp. 126, 146), quoted there, will refute van Hoepen's accusation that I "let Spath say things which Spath never said."

(5) It is true that van Hoepen did not say that *Dipoloceras bouchardianum* occurs in South Africa. Therefore, instead of saying that "*D. bouchardianum* occurs in Zululand earlier than *D. cristatum*," I ought to have said this of the group of *D. bouchardianum* (in which I include van Hoepen's genus *Riconoceras*, just as he includes, though doubtfully, *D. bouchardianum* in this genus of his). The reader will decide whether this slight inexactitude justifies van Hoepen's accusation that I play "a dangerous game with the honour, good name and scientific responsibility of a colleague."

(6) Nowhere in my discussion of van Hoepen's monograph did I ever question the wealth and importance of his fauna, or sequence of faunas, from Zululand, but I deplored the lack of attention paid by him to other faunas than his own.

Critical analysis of the twenty-two new genera and four new families—not to speak of the much more numerous new species—established in van Hoepen's preliminary report (1931) and in Parts I to IV of his monograph (1941–1946) would require many months of careful study which I can not spend on this work just now or in the near future. I realize that I have to be extremely cautious lest I be once more accused of "assertions without proof." Still, after a preliminary, though careful examination of Parts II–IV (1942–1946) which I saw only after my 1942 discussion of Part I (1941), I cannot but voice my *impression* that the characters on which those new genera are based should, in general, not be granted generic rank.

REFERENCES

HAAS, OTTO, 1942, The Vernay Collection of Cretaceous (Albian) ammonites from Angola: Amer. Mus. Nat. Hist. Bull., vol. 81, pp. 1–224, pls. 1–47, 33 text figs., 2 tables.

——, and GEORGE GAYLORD SIMPSON, 1946, Analysis of some phylogenetic terms, with attempts at redefinition: Amer. Philos. Soc. Proc., vol. 90, pp. 319–349.

SCHINDEWOLF, O. H., 1927, Prinzipienfragen der biologischen Systematik: Palaeont. Zeitschr., vol. 9, pp. 122–169, 2 text figs.

SPATH, L. F., 1922, On Cretaceous Ammonoidea from Angola, collected by Professor J. W. Gregory, D.Sc. F.R.S.: Roy. Soc. Edinburgh Trans., vol. 53, pp. 91–160, text figs. A–D, pls., 1–4.

——, 1938, Catalogue of the ammonites of the Liassic family Liparoceratidae in the British Museum (Natural History); London ix+191 pp., 17 text figs., 26 pls.

VAN HOEPEN, E. C. N., 1931, Die Krytfauna van Soeloeland. 2. Voorlopige Beskrywing van enige Soeloelandse Ammoniete. 1. Lophoceras, Rhytidoceras, Drepanoceras en Deiradoceras: Nasion. Mus. Bloemfontein Paleont. Navors., pt. I, 2d piece, pp. 39–54, text figs. 1–14.

——, 1941, 1942, 1944, 1946, Die gekielde Ammoniete van die Suid-Afrikaanse Gault, I–IV: *Ibid.*, 3d–6th pieces, pp. 55–260, text figs. 1–268, pls. 8–26.

——, 1946, 7. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. V. Monophyletism or polyphyletism in connection with ammonites of the South African Gault: *Ibid.*, 7th piece, pp. 261–271 (Afrikaans version: Wetenskap en Kuns, Nov., 1945, pp. 19–38).

JOURNAL OF PALEONTOLOGY, VOL. 22, NO. 1, PP. 106–109, JANUARY 1948

NOMENCLATURAL NOTES

LECTOTYPE OF *SPIROPLECTAMMINA GRZYBOWSKII*

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Dr. Brooks F. Ellis kindly has brought to my attention an inadvertent absurdity in type designation that escaped my notice in the preparation of a recent paper on Cretaceous Foraminifera (Frizzell, 1943). *Spiroplectammina gryzbowskii* Frizzell was proposed with three holotypes. One of these was due to a typographical error and has been eliminated from further consideration (Frizzell, 1944). The others, originating in the citation of two figures of different specimens rather than a single illustration, must be treated as having the status of syntypes in the original reference. "The holotype selected is that specimen in the Cushman collection figured by Cushman and Jarvis (1928, p. 101, pl. 14, figs. 13 [megalospheric] 14 [microspheric])" (Frizzell, 1943, p. 339). Although it was my intention to indicate only one of these as the type of the species, I cannot at this date know which with certainty, nor can the error be rectified without formal treatment in publication. I therefore designate as lectotype of *Spiroplectammina grzybowskii* the microspheric specimen from Trinidad illustrated as *Spiroplectoides clotho* (Grzybowski) by Cushman and Jarvis (1928, p. 101) on plate 14, figure 14.

REFERENCES

CUSHMAN, J. A., and JARVIS, P. W., 1928, Cretaceous Foraminifera from Trinidad: Cushman Lab. Foram. Research, Contr., vol. 4, pt. 4, pp. 85–103, pls. 12–14.

FRIZZELL, D. L., 1943, Upper Cretaceous Foraminifera from northwestern Peru: Jour. Paleontology, vol. 17, no. 4, pp. 331–353, pls. 55–57.

——, 1944, Upper Cretaceous Foraminifera from northwestern Peru: Corrections: Jour. Paleontology, vol. 18, no. 2, p. 218.

IMPLICATIONS OF *PRIONOTROPIS* MEEK BEING A HOMONYM

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Some time ago (Haas, 1946, p. 218) I pointed out that only under a narrow circumscription of genera, as favored by modern ammonite taxonomy, can generic separation of *Prionotropis* and *Prionocyclus* be justified. I continued that, "should . . . only subgeneric rank be granted to the *woollgari* group, it would have to be treated again, as it was by Meek, as the subgenus *Prionotropis* of the genus *Prionocyclus sensu lato*," since the second generic name (1871) antedates the first, proposed in 1876. However, I then suggested "to maintain both *Prionotropis* and *Prionocyclus* as independent genera, though . . . fully aware of their close relationship." One of the reasons of convenience for my above suggestion was to avoid the issue whether or not to replace Hyatt's family name Prionotropidae by Prionocyclidae.

Quite recently Breistroffer (1947) disclosed *Prionotropis* Meek, 1876, to be a homonym of *Prionotropis* Fieber, 1853, a genus of Orthoptera. Breistroffer proposes the new name *Collignoniceras* to replace *Prionotropis* Meek and considers replacement of Prionotropidae Hyatt, 1900, by Prionocyclidae Haas, 1946, as a necessary consequence of the invalidity of Meek's generic name.

Since Breistroffer's paper was published in a French periodical readily accessible to only very few, if any, American students (see Union List of Serials, 1943, p. 2622), it seems

advisable here to repeat his nomenclatural propositions; it should be added that his paper affects many more generic names of Jurassic and Cretaceous ammonites.

Two ways seem to be open for future taxonomic usage concerning *Prionotropis* Meek, *non* Fieber: (a) to relegate it to merely subgeneric rank under the designation *Prionocyclus* (*Collignoniceras*), or (b) to keep it, under its new name, as an independent genus on equal standing with *Prionocyclus*. The first alternative would automatically take care of the fact that both of Meek's names, *Prionocyclus* and *Prionotropis*, have been familiar to American paleontologists for more than seven decades, whereas *Collignoniceras* is quite new to them. However, this fact should be given due consideration also if the second alternative is followed, by adding, at least for a period of transition, to the new generic name *Collignoniceras* "(= *Prionotropis* Meek, *non* Fieber)."

REFERENCES

BRIESTROFFER, MAURICE, 1947, Notes de Nomenclature paléozoologique: Procés-Verbaux Mensuels Soc. Scientif. du Dauphiné. 26th year, no. 195, 5 pp.

HAAS, OTTO, 1946, Intraspecific variation in, and ontogeny of, *Prionotropis woollgari* and *Prionocyclus wyomingensis:* Amer. Mus. Nat. Hist., Bull., vol. 86, art. 4, pp. 141–224, pls. 11–24, 108 text figs.

GRINNELLASPIS, NEW NAME REPLACING *ACTINOPELTIS* POULSEN, 1946

CHR. POULSEN
Mineralogical and Geological Museum, University of Copenhagen

Dr. F. Prantl and Dr. A. Přibyl have called my attention to the fact that the name *Actinopeltis* recently proposed by me for a genus of Ordovician trilobites (Notes on Cambro-Ordovician fossils collected by the Oxford University Ellesmere Land Expedition, 1934–1935; Geol. Soc. London Quart. Journ., vol. 102, pt. 3, 1946, p. 324) has been used previously by Hawle and Corda, 1847, for a genus of the cyrtometopoid Cheiruridae. I therefore propose to substitute for *Actinopeltis* Poulsen, not Hawle and Corda, the new generic name *Grinnellaspis*, the genotype becoming *Grinnellaspis feildeni* (Poulsen, 1946).

THE APPLICATION OF OPINION 138 TO SOME RECENTLY PUBLISHED NAMES

J. BROOKES KNIGHT AND J. MARVIN WELLER

In a recent issue of this Journal,[1] the Joint Committee on Zoological Nomemclature for Paleontology in America called attention to Opinion 138 issued by the International Commission on Zoological Nomenclature and published in 1942.[2] This Opinion appears to provide a trap for the unwary taxonomist because it is interpretive of Article 25 of the International Rules of Zoological Nomenclature and therefore may be considered to apply retroactively to January 1, 1931 when the present form of this Article became effective. As previously noted, Opinion 138 provides that an author replacing a preoccupied name (junior homonym) must cite the author of the name replaced, the year of its publication and give a definite bibliographic reference, *including the page number*. In practice the author and date have been cited almost universally and

[1] Jour. Paleontology, vol. 21, 1947, p. 400.
[2] Opinions rendered by the International Commission on Zoological Nomenclature, vol. 2A, pp. 29–34, 1942.

some sort of bibliographic reference commonly has been provided but many authors have failed to give the page number. If Opinion 138 is to be strictly followed, this means that there exists in the literature a very large number of names introduced since 1930 that were improperly proposed and consequently are invalid and unavailable. Potentially, this situation constitutes a terrifyingly fertile source for nomenclatural confusion.

In order to obtain some idea of the number of such improperly proposed names published by American paleontologists, a canvass was made of volumes 19, 20 and the first four numbers of volume 21 of this Journal. Only the 21 articles published expressly for the purpose of proposing new names for preoccupied generic and specific names were examined. Undoubtedly other new names were introduced in papers not published specifically for that purpose. In these special articles 32 new names were proposed to replace homonyms. Of these, ten or nearly one-third do not comply with the provisions of Article 25 as interpreted by Opinion 138 and therefore they may be invalid.

We feel that our point can be driven home most effectively by lisitng these ten improperly proposed names and trust that their authors will forgive us for using them as examples of possible infractions of the Rules with respect to a detail concerning which they were, no doubt, uninformed.

Flower published three new names.[3] *Lingula clarkei* Flower, a substitute for *L. elliptica* Clarke is certainly valid because a full bibliographic reference to the name replaced including page number is presented. *Pterinea nylanderi* Flower,[4] proposed to replace *P. brisa* Clarke, and *Modiolopsis clintonensis*, a substitute for *M. ovata* Hall, are of questionable validity because page references were omitted. Similarly, *Crepicephalus edwardsi* Raasch and Lochman[5] substituted for *C. oweni* Raasch and Lochman; *Saarolepis* Robertson,[6] to replace *Anaspis* Robertson; *Howellella* Kozlowski,[7] for *Crispella* Kozlowski; *Rotalia bartoniana* ten Dam,[8] for *R. granulosa* ten Dam; *Glandulina peelensis* ten Dam, for *G. nitida* ten Dam; *Cristellaria teschi* ten Dam and Reinhold,[9] for *C. grandis* ten Dam and Reinhold; and *Vaginulina obtusicostata* ten Dam and Reinhold, for *V. striatula* ten Dam and Reinhold, are all improperly proposed because of their authors' failure to cite, as parts of their otherwise complete bibliographic references, the pages on which the preoccupied names were published. Finally, an outstanding example of an improperly proposed new name is *Bicorbis* Condra and Elias,[10] introduced to replace *Bicorbula*, for which neither author, year, nor any bibliographic reference was presented although a complete reference was given for *Bicorbula* Fisher, the preoccupying homonym. This name complies with none of the provisions of Article 25 and is unequivocally invalid.

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[3] Flower, R. H., New names for three Paleozoic fossil homonyms, Jour. Paleontology, vol. 19, 1945, p. 76.

[4] Flower made a serious nomenclatural blunder in his statement that "*P. brisa vexillum* Clarke will become *P. nylanderi vexillum*." We have not looked up the literature or synonymy of *P. brisa* but on the basis of the information furnished by Flower this cannot be correct because the subspecies name *vexillum* of Clarke has priority over Flower's new name and becomes the specific name. The nomenclaturally typical subspecies becomes *P. vexillum vexillum*, and the formerly typical subspecies that was known as *P. brisa brisa* becomes *P. vexillum nylanderi* if Flower's name is considered valid. Article 11 of the Rules states "specific and subspecific names . . . are co-ordinate, that is, they are of the same value."

[5] Raasch, G. O., and Lochman, C., *Crepicephalus edwardsi* Raasch, new name for *Crepicephalus oweni* Raasch, Jour. Paleontology, vol. 19, 1945, p. 77. Parenthetically, what a mistaken and needless complication of authorship to be inflicted on posterity!

[6] Robertson, G. M., *Saarolepis*, new name for *Anaspis* Robertson, 1941, Jour. Paleontology, vol. 19, 1945, p. 77.

[7] Kozlowski, R., *Howellella*, a new name for *Crispella* Kozlowski, 1929, Jour. Paleontology, vol. 20, 1946, p. 295.

[8] ten Dam, A., New names for two species of Foraminifera from the Lower Tertiary of the Netherlands, Jour. Paleontology, vol. 21, 1947, p. 186.

[9] ten Dam, A., and Reinhold, T., New names for two species of foraminifera from the Middle Miocene of the Netherlands, Jour. Paleontology, vol. 21, 1947, p. 186.

[10] Condra, G. E., and Elias, M. K., *Bicorbis arizonica* Condra and Elias, new name for *B. arizonica*, Jour. Paleontology, vol. 19, 1945, p. 411.

Further search of the literature would multiply these examples indefinitely. Obviously a large percentage of substitute names has been improperly proposed and may be invalid because of authors' ignorance of the rules that govern such matters, failure to interpret them properly, uncertainties inherent in the rules themselves, or simple carelessness.

We have not tried to trace the history of any of the foregoing names but, by chance, we have at least a partial record of one of them, *Howellella* Kozlowski, published improperly in May, 1946. It has implications illustrating the absurdities that may arise.

In February, 1947, Howell published a paper[11] in which he dealt with the name *Howellella*. In it he noted the previous publication of the name and gave the full reference to *Crispella*, which it was intended to replace, including the page reference that Kozlowski had omitted. Thus it may be that the name *Howellella* was first published validly by Howell in this paper. If so, the name dates from Howell's publication of it and Howell, not Kozlowski, is the author of a name dedicated to himself!

Practically all paleontologists now recognize that the International Rules of Zoological Nomenclature should be implicitly followed and strictly interpreted because this is the only means of maintaining nomenclatural stability. The Rules, however, unfortunately are not perfect and unforeseen situations arise in which their interpretation is uncertain. A case in point, of the utmost importance in connection with the subject under discussion, is the status of Opinions of the International Commission. Although no explicit authoritative statement has been issued by the Commission or by the Congress, it seems logical to conclude that Opinions concerned with interpretations of the Rules are comparable to decisions of a supreme court and thus become part of the law. If this principle be accepted, the improperly proposed names mentioned above, and others like them, must be invalid.

Most paleontologists know of the International Rules and try to conform to them in their work but the Opinions are poorly known and few persons have consulted the full texts which have never attained more than very moderate circulation. Moreover the publication of Opinions has often been delayed for years. Opinion 138, for example, adopted in 1935 was not published until 1942. If Opinions interpretive of the Rules possess the force of law, this situation certainly creates serious difficulties for all active investigators even though circumstances render the Commission blameless for the delay.

In the case of Opinion 138 most taxonomists had no reasonable means of learning of the action that the Commission had taken for seven years, with regard to the provisions of an Article that had already been in effect for five years. Thus all work published during the course of twelve years, in which authors were not more than ordinarily careful to give full bibliographic references, may contain names that are invalid on this account. These names may be the cause of future confusion.

This and other matters related particularly to the amendations to Article 25, effective since 1930, pose disturbing problems that should be reviewed and clarified. Certain persons and organizations specially interested in zoological nomenclature are considering means for presenting these matters before the next International Zoological Congress. Of course the action that may be taken by that body cannot be predicted. Because of this the only safe procedure for paleontologists to take is to make certain that future introductions of substitute names for homonyms comply precisely with the requirements of Opinion 138. Thus names so proposed cannot be called in question regardless of the status eventually assigned to those introduced up to this time.

Opinions may differ regarding the action that should be taken by authors whose substitute names do not comply with all requirements of Opinion 138. These names might be reintroduced in completely proper form but this would require the publication of a large number of otherwise useless notes. We recommend that this not be done at present in the hope and expectation that names lacking only page references will eventually become legalized. We desire to

[11] Howell, B. F., Spiriferoid brachiopods new to the Silurian Cobleskill formation of New York, Bull. Wagner Free Inst. Sci., vol. 22, 1947, pp. 1–10.

emphasize most strongly, however, the necessity for full bibliographic references including page numbers in all proposals of new substitute names, and particularly, call the importance of this matter to the attention of editors.

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